

Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products

**Quarterly Report
August - November 1994**

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December 1994

Work Performed Under Contract No.: DE-AC21-94MC31175

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
University of Pittsburgh
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MASTER

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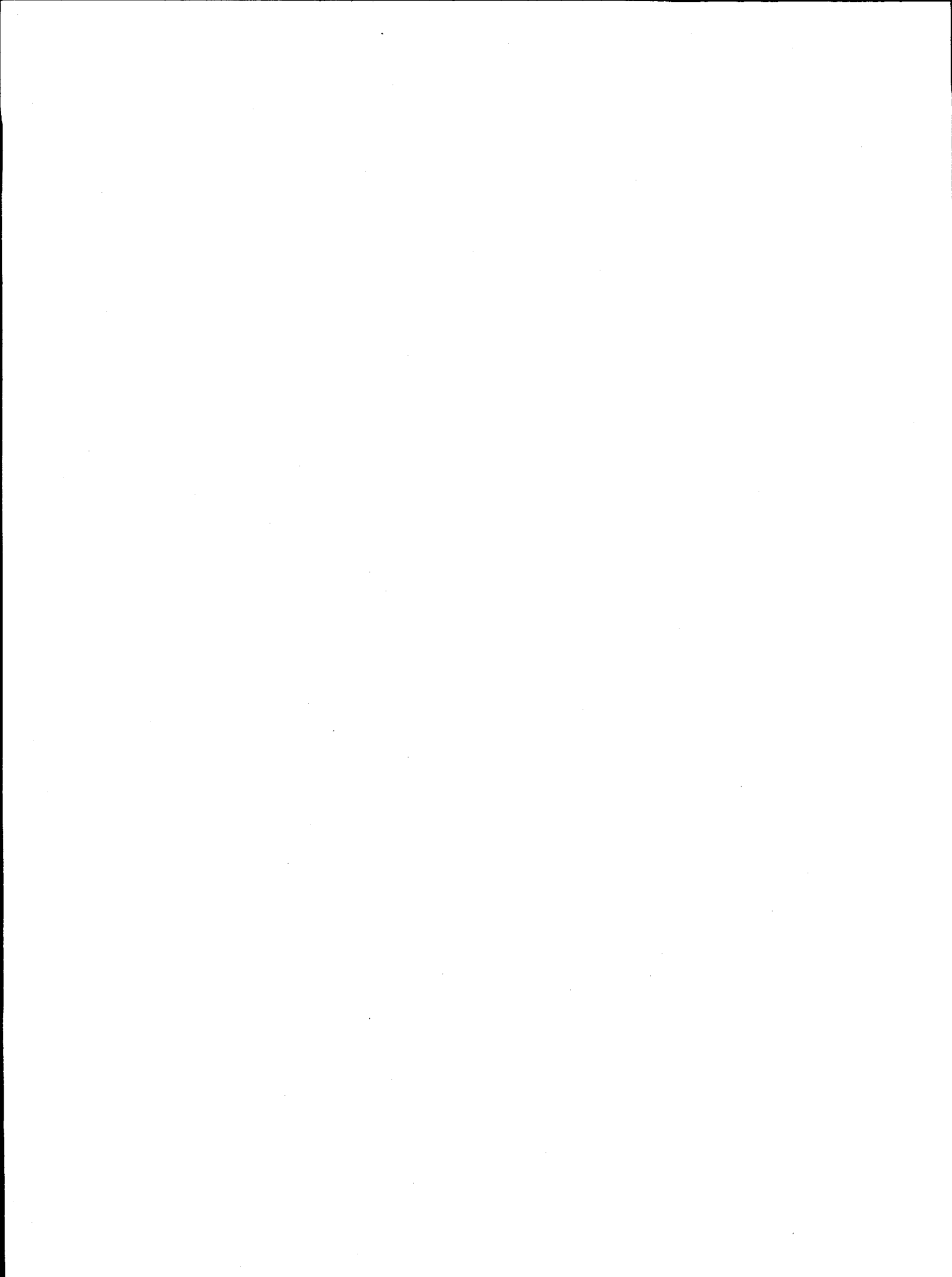


TABLE OF CONTENTS

Executive Summary	1
Introduction	3
Objectives and Approach of the Project	4
Activity during the Quarter	8
Plans for the Next Quarter	18
Appendix A - Reports of Meetings, Telephone Conversations, and Visits	20
Appendix B - By-Product Review	46
Appendix C - Review of Wastes and Treatments	67
Appendix D - METC's Record of the Kick-Off Meeting	69

EXECUTIVE SUMMARY

The project was initiated on August 18, 1994.

Objectives and Approach of the Project

The project's objectives are:

- generally to provide useful information and data on the ability of new sources of chemical treatment materials, in this case by-products from advanced clean coal technologies, to be used by the hazardous waste community.
- commercially to link the producers of by-product with operators of hazardous waste treatment facilities in a mutually profitable manner.
- specifically to evaluate treatment of up to ten characteristic metal-laden hazardous wastes with up to four by-products, first in laboratory-scale tests (Phase One) and then in commercial-scale tests (Phase Two).

Limiting treatment to only characteristic metal-laden hazardous waste in the project is an important constraint. This type of hazardous waste may be disposed as a non-hazardous waste when the hazardous characteristics are eliminated by treatment.

Samples of the four by-products are being collected and characterized by Dravo Lime Company (DLC). Samples of ten hazardous wastes are being collected, analyzed and treated by Mill Service, Inc. (MSI). Samples of the treated wastes will be analyzed at the University of Pittsburgh (Pitt) which is also coordinating the project.

Activity during the Quarter

The draft of the test plan was issued on September 14, 1994 for approval by the Morgantown Energy technology center (METC). Following suggestions by METC for changes, a final draft was submitted on October 17, 1994 and approved soon thereafter.

Three by-products, suggested in the proposal for this project, continued to be specified in the test plan:

- residue from a coal-fired circulating fluid bed combustor, located at the AES Thames River Plant, and supplied by Anker Energy Corporation.
- dry scrubber residue from the Carneys Point Cogeneration Plant and supplied by CONSOL Inc.
- residue from a coal-waste-fired CFBC, operated by the Ebensburg Power Company.

The original fourth by-product being unavailable, an alternative one was selected after

a lengthy set of consultations with three by-product producers and a number of staff members at both METC and the Pittsburgh Energy Technology Center (PETC). The selected residue is produced by the coal-fired pressurized fluid bed combustor (PFBC) at the Tidd Station of Ohio Power company, a subsidiary of American Electric Power Corporation.

In the process of seeking operating details of the AES Thames River Plant, the project team learned that it had insufficient authorization to use the by-product of that plant for treatment of hazardous waste. Pitt was advised to prepare a comprehensive proposal and submit it to Energy Resources & Logistics, Inc., who would approach AES and JTM, the ash broker for AES, for the necessary approval.

DLC has collected three samples each from Anker Energy Corporation and Ebensburg Power Company, and one sample from the Tidd Station. It has begun analysis of all seven samples. MSI has received one by-product from DLC, has identified one hazardous waste, and has begun qualifying it for the project. Pitt has prepared a laboratory manual for its portion of the project, has examined all equipment, has reviewed all procedures, and has begun examination of two surrogate samples.

Pitt has also prepared a first draft of a white paper on "Characterization of Advanced Clean Coal Technology By-Products" and a brief annotated bibliography on the stabilization and solidification of hazardous waste.

The project's formal kick-off meeting was held at METC on November 10, 1994.

Plans for the Next Quarter

The remaining thirty-three by-product samples will be collected by DLC, who will also complete characterization of the seven initial by-product samples and will begin to characterize those collected in the second reporting period.

Laboratory-scale tests of stabilization/solidification will be applied to approximately nine waste/by-product combinations in the second quarter. Portions of the treated wastes generated by MSI will be sent to Pitt for further analyses and testing.

Pitt will develop the computerized data base which will contain all of the data from the project and allow comprehensive analyses and graphical displays of results. Pitt will also continue to augment the white paper on "Characterization of Advanced Clean Coal Technology By-Products" and it will begin drafting a second white paper on "Characterization, Stabilization and Solidification of Hazardous Wastes."

INTRODUCTION

This first quarterly report describes work during the first three months of the University of Pittsburgh's (Pitt's) project on the "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products."

Participating with Pitt on this project are Dravo Lime Company (DLC), Mill Service, Inc. (MSI) and the Center for Hazardous Materials Research (CHMR).

The report states the goals of the project - both general and specific - and then describes the activities of the project team during the reporting period. All of this work has been organizational and developmental in nature. No data has yet been collected. Technical details and data will appear for the first time in the second quarterly report and be the major topic of subsequent reports.

OBJECTIVES AND APPROACH OF THE PROJECT

Objectives of the Project

The general objective of the laboratory studies in Phase One and subsequent field studies in Phase Two of this project is to provide useful information and data on the ability of new sources of chemical treatment materials, in this case by-products from advanced clean coal technologies, to be used by the hazardous waste management community.

These studies fall into two categories - characterization of selected critical properties of the by-products and observation of their ability to stabilize and solidify characteristic metal-laden solid hazardous wastes. The characterization studies are designed to assess the chemical, mineralogical, physical and engineering properties of dry combustion/desulfurization by-products. To the extent possible within the limited number of by-product samples collected during this project, the following two issues will be examined: (1) how the measured properties are affected by the type of process utilized and (2) how specific operating conditions within the various processes affect the measured properties of the by-products. The stabilization and solidification studies are designed to assess the ability of these by-products to immobilize the metals present in the waste and to assess the compressive strength of the resulting non-hazardous product.

A more commercial objective of the project is to link the producers of by-product with operators of hazardous waste treatment facilities in a mutually profitable manner. From the treatment facility operators' side, new sources of treatment material, which can stabilize and solidify their feed wastes, will be added to their material source list. From the producers' side of the equation, new uses for by-products of their advanced coal combustors and desulfurizers will be added to their customer lists. These producers have implemented various emission control technologies at their coal-fired electric power plants and are studying a number of others. The technologies currently in use generate significant amounts of by-products with limited commercial value. Consequently, much of the by-products have to be disposed as solid wastes. In particular, companies employing wet scrubber technologies for the desulfurization of flue gases have found few alternatives to disposal for the sludges generated in the processes due to the excess moisture present in the by-product. The development of dry desulfurization technologies offers more promise that the process by-products may have some beneficial application, such as that to be studied in this project.

The specific objective of the project, as provided in the "Statement of Cooperative Agreement Objectives" of the contract document is:

The objective of this project is to evaluate treatment of [characteristic] metal-laden hazardous wastes using solid by-products generated by Clean Coal Technologies (CCT). The project is divided into two phases. In Phase 1, the participant will evaluate up to 10 sources of [characteristic] metal-laden hazardous wastes and up to 4 sources of CCT solid by-products in laboratory-scale tests. In Phase 2, the participant will evaluate treatment of the [characteristic] metal-laden hazardous waste using CCT solid by-products in 20-ton batches. Complete physical and chemical characterization of the CCT solid by-products, and treated and untreated [characteristic] metal-laden

hazardous waste will be performed in both phases. An economic analysis is included in both phases to assess the commercial viability of treating metal-laden hazardous waste with CCT solid by-products.

Characteristic Metal-Laden Hazardous Wastes

The limitation of the project to characteristic metal-laden hazardous waste is important. Federal regulations and many state regulations require generators of solid wastes to determine if the wastes they generate are hazardous. The determination process often requires the generators to analyze the wastes, or leachates produced when the wastes are mixed with an extraction fluid, and compare the results of that analysis to a published list that defines which parameters are of concern and the concentrations at which a waste containing those parameters is considered hazardous. Wastes that contain constituents on the list at concentrations that equal or exceed the published concentrations are considered to be characteristically hazardous (unless they are specifically excluded) and said to exhibit the toxicity characteristic. Among the parameters included on the toxicity characteristic list published in the Federal regulations¹ are eight metals. These metals, and the concentrations at which a waste (or waste extract) containing them is considered hazardous, are -

Metal Parameter	Hazardous Concentration (mg/l)
Arsenic (As)	5.0
Barium (Ba)	100.0
Cadmium (Cd)	1.0
Chromium (Cr)	5.0
Lead (Pb)	5.0
Mercury (Hg)	0.2
Selenium (Se)	1.0
Silver (Ag)	5.0

Once a waste is determined to be hazardous, generators are restricted from disposing that waste anywhere in the United States. Prior to disposal, the waste must be treated to an extent equivalent to that which can be achieved by the technology the United States Environmental Protection Agency (USEPA) has determined is demonstrated to be the best and is available to the generator.² This technology is known as the "Best Demonstrated Available Technology" or BDAT. The purpose of the treatment prior to disposal is to reduce the likelihood of migration of hazardous waste constituents from the waste. Wastes that are treated to meet the established standards can be disposed.

¹ See 40 CFR 261.24.

² The USEPA does not mandate the use of a specific technology, except in certain situations. Rather, the USEPA establishes treatment limits based on the use of the best technology in treating the waste, then allows generators to use any technology they choose, other than impermissible dilution, to achieve the limits.

For wastes that exhibit the metal toxicity characteristics, the USEPA has established the BDAT treatment standards as follows³:

Metal Parameter	BDAT Treatment Standard (mg/l) ⁴
Arsenic (As)	5.0
Barium (Ba)	100.0
Cadmium (Cd)	1.0
Chromium (Cr)	5.0
Lead (Pb)	5.0
Mercury (Hg) ⁵	0.20
Selenium (Se)	5.7
Silver (Ag)	5.0

As is apparent, all of the treatment standards except the standard established for selenium mimic the concentrations at which the waste is considered to exhibit the toxicity characteristic. Consequently, by treating a waste that exhibits a metal toxicity characteristic to meet the treatment standard (other than selenium), *the waste is no longer considered to exhibit that characteristic and can be disposed as a non-hazardous waste* (unless state law requires otherwise). In the case of selenium, a waste treated to meet the treatment standard may still require disposal as a hazardous waste if the concentration in the treatment residue equals or exceeds the toxicity characteristic level.

Approach

The project is divided into two one-year phases. In Phase One, samples of four clean coal technology by-products are being collected by Dravo Lime Company (DLC) and characterized, ten samples of characteristic metal-laden hazardous wastes are being collected and characterized, and laboratory-scale treatments of each of the ten wastes with each of the four by-products are being performed at the Yukon Plant of Mill Service, Inc. (MSI) in a manner identical to the commercial treatability tests used at that site.

The Yukon Plant of MSI is an industrial waste treatment, storage and disposal (TSD) facility authorized by permits from the Commonwealth of Pennsylvania, Department of Environmental Resources (PADER). The facility is authorized to treat and store certain hazardous wastes by Hazardous Waste Permit No. PAD004835146 and is authorized to treat, store and dispose certain non-hazardous wastes by Solid Waste Permit No. 301071. The facility routinely evaluates metal-bearing wastes to determine if the wastes can be treated to

³ See 40 CFR 268.

⁴ The concentrations presented are for the metals present in nonwastewaters, that is, wastes that do not contain less than 1 % (by weight) total suspended solids or less than 1 % (by weight) total organic carbon. The same metals present in wastewaters or in wastes considered hazardous for other reasons, such as listed wastes, may be subject to different treatment standards.

⁵ The mercury treatment standard applies only to wastes that contain less than 260 mg/kg mercury. Wastes that contain higher mercury concentrations are subject to a different treatment standard.

below the applicable treatment standards. These evaluations are conducted in an on-site laboratory that has filed all of the required notifications.⁶ The PADER is notified of the metal toxicity characteristic wastes that the laboratory successfully treats and that MSI intends to manage prior to actual management of the waste. The wastes are then accepted for treatment and disposal.

Samples of the treated wastes are being sent to the University of Pittsburgh (Pitt) for further characterization. Pitt returns all of the unused waste treatment residue samples to the Yukon Plant for disposal. Those materials which MSI is capable of disposing on-site (following additional treatment, if necessary) are being so disposed. Those materials which it is not capable of disposing on-site are being packaged and managed at permitted disposal outlets available to MSI. Wastes and treatment residues that continue to exhibit hazardous waste characteristics are being disposed at an authorized hazardous waste facility.

In Phase Two of the project, ten commercial-scale treatments (10-ton batches each containing approximately five tons each of waste and by-product) will be conducted at the Yukon Plant. Again, Pitt will perform further characterization of the treated wastes. Disposal of all material will be carried out as in Phase One.

⁶ See 40 CFR 261.4(f) and 25 Pa Code 261.4(d).

ACTIVITY DURING THE QUARTER

The activity on the project during the first quarter of Phase One has fallen into eight areas:

- Developing the test plan
- Identifying the fourth by-product
- Visits and discussions with by-product producers
- Collection of by-products
- Laboratory work
- Background development
- Attendance at two meetings associated with the Morgantown Energy Technology Center (METC)
- Presenting the project's kick-off meeting

A local project kick-off meeting was held at the University of Pittsburgh on September 2, 1994 to begin the project on a sound footing. Team members from Pitt, DLC, MSI and CHMR all participated in this meeting.

To coordinate work at three major locations (Pitt, DLC and MSI) members of the project team spoke frequently by telephone and participated in occasional field visits. The members of the project team from Pitt met regularly once a week (except for those periods when neither the principal investigator or the co-principal investigator were available). Appendix A contains a detailed record of the meetings, telephone conversations and field trips conducted during this quarter.

Test Plan

Task 2 of Phase One was defined in the contract as the "preparation of a comprehensive laboratory-scale test plan to evaluate stabilization of metal-laden hazardous waste with solid by-products from Clean Coal Technologies." The contract set forth the elements of the test plan and called for the document to be submitted by September 18, 1994.

At the request of Pitt, DLC and MSI provided detailed background and comprehensive descriptions of the laboratory-scale work to be performed at their facilities. The University prepared a first draft of the plan on September 7, 1994, which was carefully reviewed by key members of the project team, and appropriate changes were made to produce a final draft. The test plan was submitted to METC on September 14, 1994.

Review comments on the test plan were issued on September 23, 1994 by METC and a revised test plan was issued by Pitt on October 17, 1994.

Fourth By-Product

The original fourth by-product, residue from Bechtel's Confined Zone Dispersion Process, was being produced from a demonstration plant at the Seward Station of the

Pennsylvania Electric Company when the proposal was submitted for this project in mid-1993. By the time the contract was awarded in August 1994, the demonstration facility had been shut down with no plans for restarting that unit or constructing a commercial one elsewhere.

Selection of an alternative fourth by-product was made from the following three candidates.

Gas Suspension Adsorption (GSA) Residue. AirPol Inc. currently produces GSA residue from its 10 MW demonstration plant at the Shawnee Fossil Plant of the Tennessee Valley Authority at West Paducah, KY, constructed and operated in cooperation with the U.S. Department of Energy in Round III of the Clean Coal Technology Program. In AirPol's GSA Process flue gas is contacted with a mixture of very fine flyash, dust particles and lime in a circulating fluidized reactor at 320°F. The residue contains unused lime and the product calcium sulfite/sulfate in the mole ratio of 30/70 which is lower in value than the FBC material already selected but higher than dry scrubber material already selected. The chemical composition of the residue is 42-48% equivalent CaCO_3 and 4-5% available (free or uncombined) CaO , based upon two analyses performed by Dravo Lime Company in April 1993 and March 1994.

Residue from a Coal-Fired Pressurized Fluid Bed Combustor (PFBC) at the Tidd Station of Ohio Power Company, a subsidiary of American Electric Power Corporation, at Brilliant, OH. This demonstration facility was constructed and is operated in cooperation with the U.S. Department of Energy in Round I of the Clean Coal Technology Program. The sorbent fed to the plant, rather than lime or limestone, is dolomite. By operating at high pressure, little of the dolomite in the residue is in the oxide form - most is present as carbonate. The residue may be obtained as bottom ash, fly ash, or a mixture. The dolomitic character of the sorbent yields a residue that is lower in pH than that produced from lime-based sorbents. This characteristic is particularly useful in stabilizing arsenic-laden waste solids. According to Dravo Lime, the chemical composition of the residue is 50-60% equivalent CaCO_3 and 1-2% available (free or uncombined) CaO .

Residue from the Tampella U-Gas Gasifier, being operated at the pilot-plant stage by Tampella at its facilities in Finland. The pilot plant has a maximum thermal input of 10 MW with coal. Two ash streams emerge from the pilot plant - a granular bottom ash and a fine filter ash (collected after sulfur removal by candle filters). While the pilot plant has the option of cofeeding coal and limestone, it also has the capability to remove hydrogen sulfide from the hot fuel gas before particulate removal by the candle filters. The pilot plant test program is continuing with coal as the main feedstock while concentrating on the testing of the external sulfur removal system and process optimization in support of the design of the Four Rivers IGCC demonstration project. The residue differs from the other five by-products in its potential for the presence of CaS and in its strong granular consistency, which might reduce the availability (releasability) of the alkalinity it contains.

In arriving at the selection of the fourth by-product, the following considerations played a role.

- The operating contract for the PFBC at the Tidd Station ends in February 1995 and there is no commitment to keep it running after that time. In addition, no commercial plant is planned.
- The Airpol GSA will continue to operate at TVA's Shawnee Station through 1995, a small demonstration unit will begin running in Spring 1996 at Hamilton, Ohio, and TVA has begun to design a large demonstration unit. TVA expressed willingness to provide samples to the project.
- The PFBC by-product from the Tidd Station, as mentioned above, contains magnesium, which will buffer the stronger lime alkalinity. This is advantageous for stabilizing arsenic.
- Up to mid-October 1994, AEP maintained a policy that its ash not be used in any remediations of CERCLA or Superfund sites. By extension, the PFBC by-product was denied to this project. However, on October 13, 1994, AEP announced a change in its policy and offered the Tidd by-product as a candidate for the fourth by-product.
- The U-Gas by-product is available only from a bench-scale unit in New Jersey and the pilot plant, mentioned earlier, in Finland. As noted above also, it contains a small amount of CaS and is agglomerated into granules, which effectively reduces the availability of the CaSO_4 contained therein.

On October 26, 1994 the project team was notified by telephone that the Tidd residue will be the fourth by-product. The basis for this decision was the interest shown in this product by the project team and METC, along with the immanent shutdown of the unit. By collecting both the Phase One and Phase Two samples, this by-product can still be fully examined in the project. The Airpol GSA residue also is of interest to the project team and METC, but it should be available for testing at anytime in the future. The U-Gas residue has several disadvantages. It likely has unavailable CaSO_4 , it contains some CaS, and it will not be available in the United States from a large-scale unit for at least several years.

Discussions with By-Product Producers

Three by-products which had been offered for use in this project at the time the work was proposed, are still being generated:

Residue from a Coal-Fired Circulating Fluid Bed Combustor (CFBC), supplied by Anker Energy Corporation. This material is produced by the cogeneration project of Applied Energy Service at its Thames River Plant near Uncasville, Connecticut. Anker Energy Corporation supplies the coal used in the plant and must backhaul the residue to its mines in West Virginia. Some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from Connecticut to West Virginia. The residue is estimated to contain 45% limestone equivalent, 28% ash and 27% $\text{CaSO}_3/\text{CaSO}_4$. It is a relatively coarse material, as it contains both bottom and fly ash from the boiler.

Dry Scrubber Residue, supplied by CONSOL Inc. from a Joy Niro Spray Drier. This material is produced by the cogeneration project of Chambers Cogeneration Limited Partnership, operated by U. S. Operating Services Company at the Carneys Point Cogeneration Plant on the grounds of DuPont's Chambers Works in New Jersey. CONSOL Inc. supplies the coal used in the plant and has agreed to backhaul the residue to its mines in western Pennsylvania and West Virginia. Some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from New Jersey to western Pennsylvania and West Virginia. The residue contains 45% fly ash, 36% $\text{CaSO}_3/\text{CaSO}_4$, 10% $\text{Ca}(\text{OH})_2$, 2% CaCO_3 , and 7% other inert material. It is comprised of agglomerates of fine materials, formed in the scrubber.

Residue from a Coal-Waste-Fired CFBC operated by the Ebensburg Power Company. Approximately 200,000 tons/year of this material is produced in an operating unit at Ebensburg, Pennsylvania. Currently it is being trucked back to the mines from which the coal wastes are derived. Some or all of this by-product could be diverted to nearby sites for beneficial use if they could be identified. The residue contains 82% ash, 12.5% limestone equivalent and 5.5% $\text{CaSO}_3/\text{CaSO}_4$. It is a relatively coarse material, as it contains both bottom and fly ash from the boiler.

The previous section describes the fourth by-product, residue from the PFBC at the Tidd Station, and how it was selected. The rest of this section will describe discussions with the companies from which the project will be obtaining each of the four by-products. These discussions focussed upon the collection of the residues.

Anker Energy Corporation et al. On September 29, 1994 details of collection of the residue from the AES Thames River Plant were worked out on a visit to the Albright Mine of the Patriot Mining Company, a subsidiary of Anker Energy Corporation (AEC), where the residue is currently being disposed. In order to obtain general information about the Thames River Plant, as well as specific details of the operating periods in which samples were produced, contact was made with the plant's Electrical and Pelletizing Superintendent. The superintendent reported that the by-product will be redirected to the Porter site in Pennsylvania beginning in February 1995 and he suggested speaking with Energy Resources and Logistics, Inc. (ERLI), the subsidiary of CSX which is responsible for the shift in repository. When contacted, a representative of ERLI stated that AEC had no authority to provide the by-product to the project. He stated further that approval for its use must come from the plant owner in response to a request made through ERLI, which he would submit through the broker for the residue, JTM. Until approval is received, the project team will embargo all samples at DLC. None will be transferred to MSI until permission is obtained from the Thames River Plant owner.

Ebensburg Power Company. On October 20, 1994 details of collection of the residue from this plant were worked out on a visit to the facility.

CONSOL Inc. On October 13, 1994 details of collection of the residue from the Carneys Point Cogeneration Plant were worked out on a visit to the research laboratories of CONSOL Inc. Sampling of this by-product could not begin until mid or late November 1994. CONSOL requires that its operating personnel perform the sampling from hopper cars. The company will collect the samples from 3-4 separate cars of different loading dates for three

separate trains that arrive weekly at the Waynesburg, PA unloading facility. DLC staff may observe the samplings.

Tidd Station. DLC is presently sampling the Tidd PFBC bottom and cyclone ash for another U.S.DOE-sponsored research project on FGD by-product utilization. Even though a meeting has not been held with Tidd plant personnel, DLC personnel will begin sampling the residue from this plant on a regular basis following the plant restart after a shut down which began on October 28, 1994. Because the project team has received only verbal approval via a telephone message to use the by-product, a letter formally requesting written approval was sent to AEP on October 30, 1994.

Collection of By-Products

Samples of three of the four by-products were collected during the reporting period.

Ebensburg Power Company. Three dry samples were collected from the storage silo for the characterization program. A portion of the first sample was sent to Pitt and MSI. It was determined that MSI would require three 5-gallon buckets or about 100 pounds for their treatability study. Thus, they were sent the required amount from the second sample. A third sample was obtained for the reactivity tests. The silo samples are a blend of bed ash and cyclone ash. Separate samples of each were obtained for comparison. An operating report representing boiler and gas cleanup conditions for the sample period was obtained.

Anker Energy Corporation. Three samples of dry cyclone ash have been taken from the top of hopper cars. The dates these cars were loaded and the car numbers were recorded. To get a sample of dry cyclone ash, the crust of about six inches has to be removed.

Tidd Station. A sample of dry cyclone ash was obtained on October 27, 1994, just before the unit was shut down, for reactivity testing. A copy of a Material Safety Data Sheet (MSDS) specifically written for the Tidd PFBC ash by-product is on file.

Laboratory Work

DLC's lab analysis program has begun testing the three samples from the Ebensburg Power Company, the three samples from Anker Energy Corporation and the first sample from the Tidd Station.

MSI has received the first by-product sample from DLC (the first one DLC collected from the Ebensburg Power Company) for analysis and use in the laboratory-scale treatability studies. MSI collected the first waste sample (a wastewater treatment plant sludge from a battery manufacturer) for analysis and use in the laboratory-scale treatability studies. The MSI program manager conducted a meeting with the MSI laboratory manager to review project activities and its schedule.

Pitt has developed a laboratory manual for its portion of the project. The manual includes descriptions of all tests to be conducted, the safety and health program, the

environmental program and the QA/QC program. Copies are available for reference and inspection in Room 976 of Benedum Engineering Hall.

The first steps in the laboratory work at Pitt have been taken. The two graduate students assisting the project have examined all equipment and reviewed all procedures. They have prepared flow charts for by-product and treated waste samples through the Pitt laboratories (see the following two pages). They are assembling the materials needed to begin the intense level of effort required when the first samples arrive from MSI. They have begun to carry out trials of the required analyses, using fly ash and light-weight concrete obtained from another Pitt project. By the end of the reporting period they had performed several TCLP and ASTM digestions and were preparing to conduct metals analyses on the extracts. They also began testing blank and spiked samples. This is the opening portion of the QA/QC portion of their work.

The co-principal investigator will be responsible for data collection and storage. Below is a summary of techniques he will use.

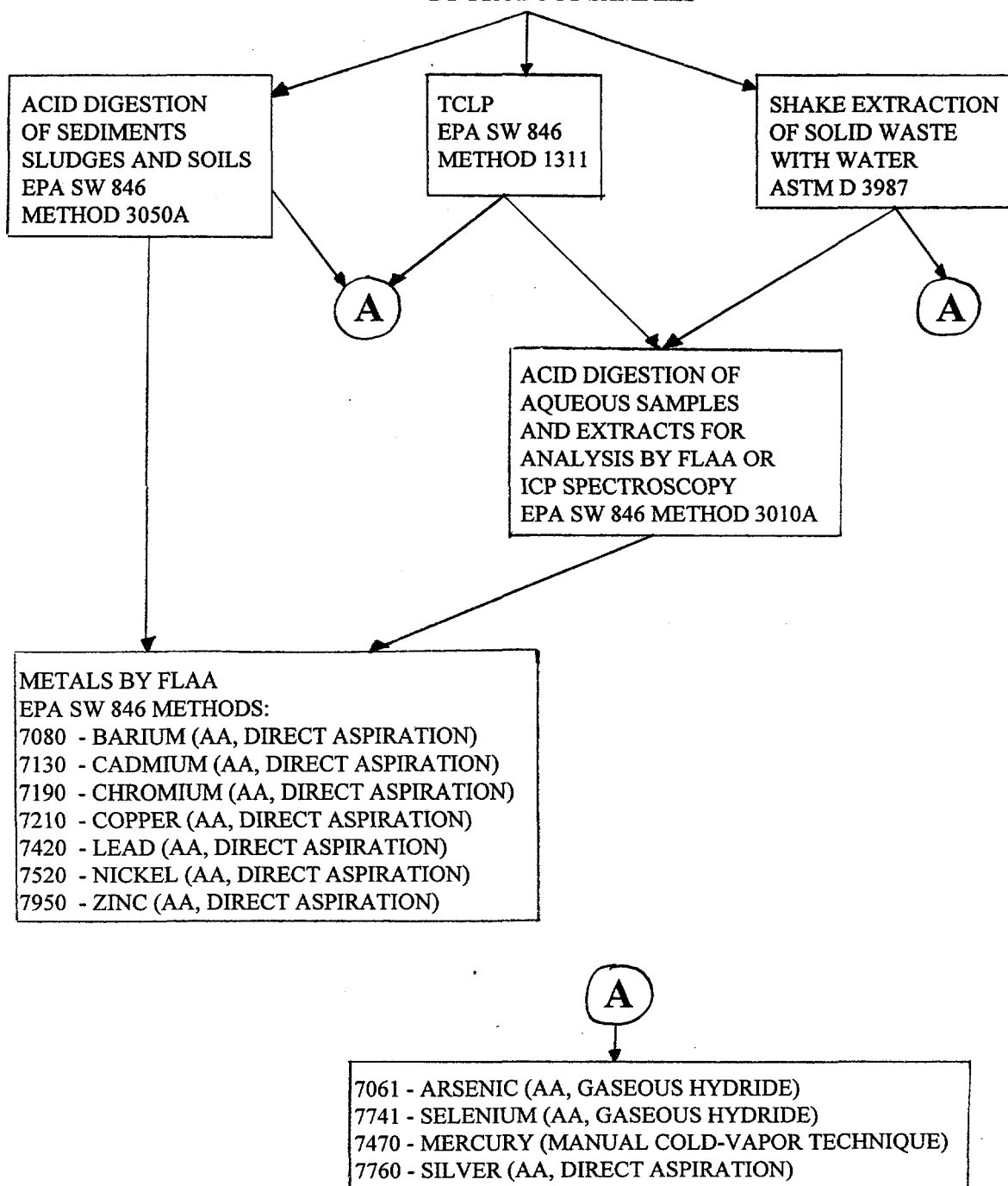
- All raw data will be collected and hand written in data books provided to each graduate student. Data books remain the property of the University of Pittsburgh and will be stored with project files for a time period well past the overall conclusion of the research effort.
- Computer spread sheets will be developed either using Lotus 2.4 for DOS or Quattro 5 for Windows. Lotus 2.4 is a format easily used by MSI, while Quattro 5 is available within the School of Engineering. Quattro 5 has distinct advantages for data manipulation and display. It also can read Lotus spreadsheets with little difficulty.
- A separate Quattro file will be opened for each of the four by-products. A separate "electronic notebook" within each file will be opened for each of the hazardous wastes treated. In this fashion, the project data will fit on four large Quattro files, each file containing a set of ten linked spreadsheets and associated graphs.
- Graduate students will maintain a working copy of each master file. However, working copies of files will be downloaded weekly to the co-principal investigator's computer for storage and data manipulation. Data files will be backed up periodically to the "file server" of the Civil and Environmental Engineering Department and to a separate tape as appropriate.

Background Development

The two graduate students from Pitt have divided the literature background survey between them. One is focussing upon the four by-products, their production, properties and general beneficial uses. The other is exploring various aspects of hazardous wastes - their properties, production, treatment (both for stabilization and solidification) and disposal.

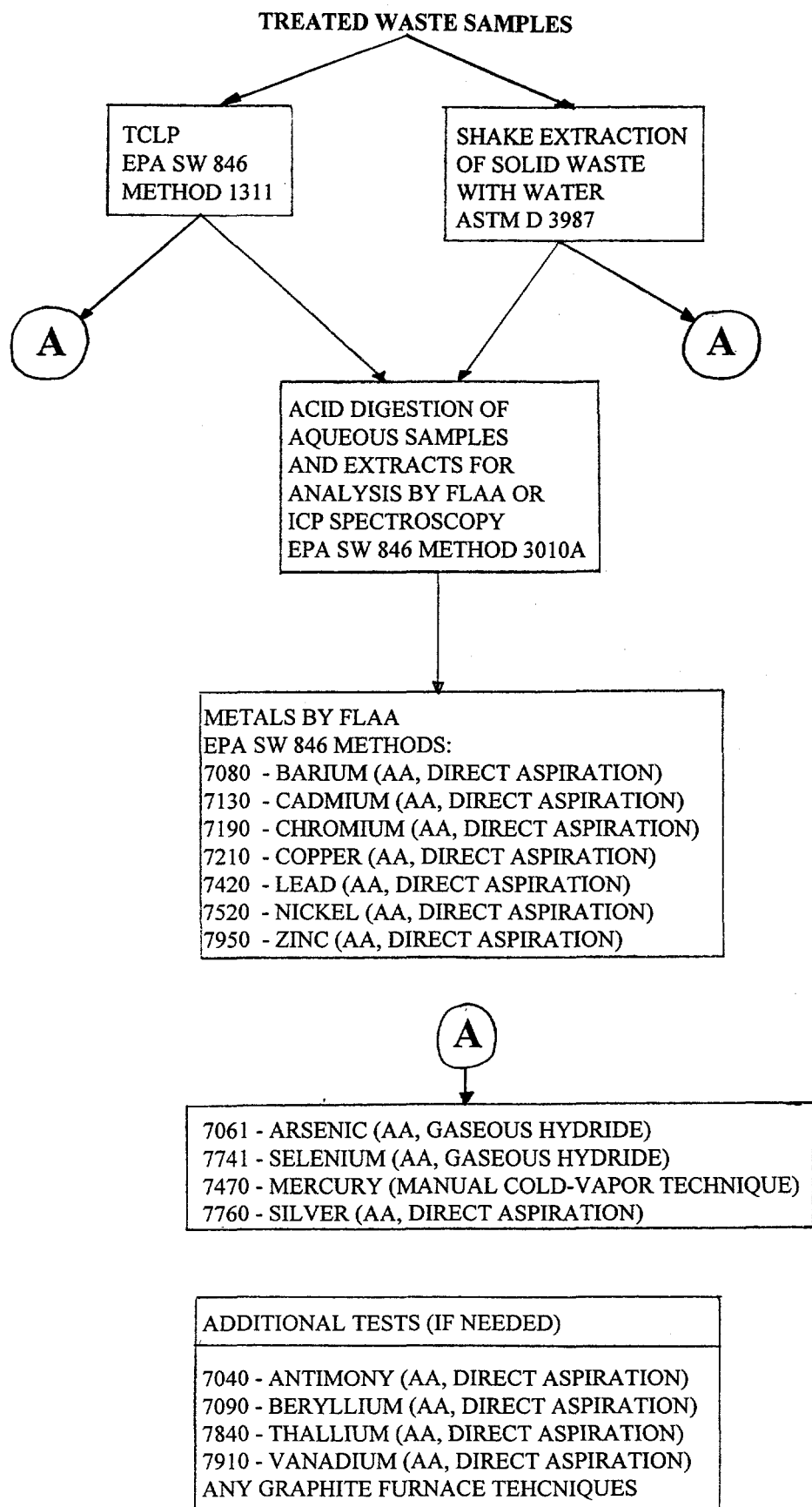
By-Products. The current draft of a white paper on "Characterization of Advanced Clean Coal Technology By-Products" is shown in Appendix B. The survey of the literature on by-products began with a visit to DLC to examine the private holdings of that company. Next,

BY-PRODUCT SAMPLES



ADDITIONAL TESTS (IF NEEDED)

7040 - ANTIMONY (AA, DIRECT ASPIRATION)
7090 - BERYLLIUM (AA, DIRECT ASPIRATION)
7840 - THALLIUM (AA, DIRECT ASPIRATION)
7910 - VANADIUM (AA, DIRECT ASPIRATION)
ANY GRAPHITE FURNACE TECHNIQUES



seminal documents were acquired from the American Coal Ash Association (ACAA). The proceedings of recent Pittsburgh Coal Conferences yielded important papers. On the visits to Ebensburg Power Company and CONSOL Inc., focussed descriptions of the plants producing the by-products collected from those two companies were requested and received. A computerized literature search has been initiated through the Bevier Engineering Library in Pitt's Benedum Engineering Hall.

Hazardous Wastes. A survey of the holdings in Bevier Library and an initial computerized literature search began the effort to develop background on hazardous waste. A two-page annotated bibliography (shown in Appendix C) has been prepared. In addition, on a visit to MSI much detailed information was provided to start a review of the characterization of the ten wastes to be treated in this project. It has been decided to await the identification of the first several specific wastes to be treated by MSI before beginning to draft the waste review.

METC-Associated Meetings

The principal investigator and the DLC program manager attended the workshop on "Mineralogical/Chemical Transformations in Coal By-Products" at the University of Kentucky on November 2, 1994. The principal investigator also attended the "Kick-Off Meeting for the Radian Corporation's Contract on Advanced Coal Technology By-Products - Management, Reuse and Disposal" at METC on November 8, 1994.

Project Kick-Off Meeting

The kick-off meeting for this project was held at METC on November 10, 1994. Two records of the meeting are presented in the appendices of this report. The record written by Pitt is found on the last three pages of Appendix A. The record written by METC is found in Appendix D.

Monthly Highlights

Here are the highlights of the first three months of the project. In each future quarterly report, this list will be reproduced and the highlights of the three months being documented in that report will be added to it.

August 18 - September 18, 1994

- Contract is signed and Phase One begins.
- Local kick-off meeting is held.
- Test plan is issued.

September 18 - October 18, 1994

- Visits are made to Patriot Mining Company and CONSOL Inc.
- Approval is given by METC to collect three by-products.
- Fourth by-product is approved.

- First by-product sample is collected - one from the Albright Mine.
- Revised test plan is issued.

October 18 - November 18, 1994

- Visit is made to Ebensburg Power Company.
- Lack of authorization to use by-product from AES Thames River Plant is uncovered.
- Laboratory work begins at DLC.
- First waste is identified by MSI.
- Kick-off meeting is held at METC.

Comparison of Progress with Milestone Chart

Only Task 2, Test Plan, was scheduled for completion during the first quarter of Phase One. By submitting the test plan by September 18, 1994, the project team met its only requirement for this reporting period.

The collection of the by-product samples has taken longer than originally anticipated. The project team had hoped to have collected a large sample of each of the four by-products by November 1, 1994, but only one of them, the by-product from the Ebensburg Power Company, was available to begin using at MSI for treatment of hazardous waste by the end of the reporting period. We hope now to have two more, the ash from the Tidd Station and the dry scrubber residue from CONSOL Inc., available for use by MSI by the end of the first month of the second quarter (December 18, 1994). Unfortunately, no firm estimate can be made as to when the fourth by-product, the residue from the AES Thames River Plant, will be able to be transferred to MSI.

The delay in collecting by-product samples may result in the need for the final ten percent (approximately) of the analyses of treated wastes, scheduled for Phase One, to be carried out during Phase Two. Mitigating this will be a reduction in the number of metals that need to be analyzed in the leachates at Pitt because of the low concentration of many of the regulated metals in the wastes initially.

PLANS FOR THE NEXT QUARTER

The activity on the project during the second quarter of Phase One will fall into five major areas:

- Collection and analysis of by-products
- Treatment of hazardous wastes
- Analysis of treated wastes
- Data collection and evaluation
- Literature survey and background development

Collection and Analysis of By-Products

The sampling and testing plan as stated in the test plan will proceed for all of the four identified sources. It is anticipated that all of the ten samples from each source will have been obtained by the end of the second quarter, February 18, 1995. MSDSs will be requested from AES Thames River Plant, Ebensburg Power Company, and CONSOL Inc. Test results from samples taken in the first quarter will have been finalized by the end of the second quarter.

A formal proposal will be submitted to Energy Resources and Logistics, Inc., requesting approval by the owner of the AES Thames River Plant to use the plant's residue in this project. Upon receipt of this approval, the large embargoed sample will be transferred to MSI.

Treatment of Hazardous Waste

Treatment of characteristic metal-laden hazardous wastes with three of the four by-products as stated in the test plan will begin. It is anticipated that at least two additional wastes will be identified and validated for treatment and that laboratory-scale treatments for both stabilization and solidification will be carried out for at least nine waste/by-product combinations by the end of the second quarter, February 18, 1995.

Analysis of Treated Wastes

Analysis of treated wastes will begin as soon as the first waste/by-product treatment has been completed. It is anticipated that, with the exception of breakage of the ninety-day cylinders, all analyses will be complete for at least six waste/by-product combinations by the end of the second quarter, February 18, 1995.

Data Collection and Evaluation

The data from all by-product and treated waste analyses performed during the second quarter will be placed in the project's computerized data base. Representative charts and figures containing this data will be generated to demonstrate the approach which will be used

to present the information collected throughout the project. Initial observations of preliminary relationships and conclusions will be provided in the second quarterly report, due on March 18, 1995.

Literature Survey and Background Development

The work begun on the literature survey and background development by the two graduate students, working on the project at Pitt, will continue on (1) the four by-products, their production, properties and general beneficial uses and (2) various aspects of hazardous wastes - their properties, production, treatment (both for stabilization and solidification) and disposal.

By-Products. The white paper on "Characterization of Advanced Clean Coal Technology By-Products" will be augmented as new information is obtained from DLC, AACA, the Electric Power Research Institute, and the four by-product producers and from the computerized literature search, which has been initiated through the Bevier Library.

Hazardous Wastes. The computerized literature search seeking background on hazardous waste will be continued. Drafting of a white paper on "Characterization, Stabilization and Solidification of Hazardous Wastes" will begin. Included in this paper will be a review of the characterization of the ten wastes to be treated by MSI in this project.

Both of the white papers will become major chapters in the topical report that is required in Task 7 of Phase One of this project.

APPENDIX A

REPORTS OF MEETINGS, TELEPHONE CONVERSATIONS, AND VISITS

RECORD OF TELEPHONE CONVERSATIONS SEPTEMBER 1, 1994

Charles Schmidt (PETC)

As compared to pressurized fluid-bed combustion (PFBC) and duct injection, Airpol's gas suspension absorber (GSA) is the closest to commercialization. Mr. Schmidt recommends speaking with Sharon Marchant about the Airpol program.

Sharon Marchant (PETC)

TVA is planning to take ownership of the 10 MW pilot plant, located at the Shawnee Station. The EPRI light-weight block production trailer may have been located at the Airpol pilot plant for a short time recently. TVA plan to scale the process up to 50 MW. The city of Hamilton, Ohio, in conjunction with the Ohio Coal Development Office, is seriously considering installing a 50 MW Airpol unit on its municipal boiler. Ms. Marchant recommends speaking with Will Goss and Frank Hsu at Airpol and to Thomas Burnett at TVA.

RECORD OF TELEPHONE CONVERSATION SEPTEMBER 2, 1994

Randall Dellefield (METC)

The PFBC technology, being piloted at the Tidd Station, appears to have reached a point beyond which it cannot soon go. B&W cannot find anyone to commercialize it. The Tidd pilot plant will operate until Spring 1995 under its current contract. Ohio Power wishes to operate it for another year beyond that time, but no contract for such an extension is yet in place. The by-product does not seem to have much cementitious character.

Foster-Wheeler's advanced PFBC technology should be commercial by 1998 at the Four Rivers Project. The process development unit (PDU) at Livingston, New Jersey, is running and producing by-product. Mr. Dellefield recommends speaking with Archie Robertson about the PDU. The pilot plant at Southern Company Services' Wilsonville, Alabama, is scheduled to start up in November 1995. He recommends speaking with Randall Rush about the pilot plant plans. Both Foster-Wheeler and Southern Company Services have a concern over the CaS that may be in the by-product from this process.

Mr. Dellefield briefly mentioned the strong commercialization of PFBC overseas. He also noted that the growth of IPPs and the deregulation of the electric utilities suggest that no large commercial new power plants will be installed in the United States until after the year 2000.

RECORD OF MEETING
SEPTEMBER 2, 1994
1132 BENEDUM ENGINEERING HALL

Present: James Cobb, Ronald Neufeld, Emanuel Schreiber, Vourneen Clifford, Jesse Pritts, Carl Bender, Joel Beeghly and Audrey Zelanko

Handed Out: Project Reporting Schedule - Phase 1
Draft Test Plan - Phase 1
Contract Document (to MSI and DLC only)

Handed to PI: Revised Test Plan - Task 3 (DLC)
Draft Quality Assurance Plan (Pitt)
Quality Assurance Plan (Antech Ltd.)
Laboratory Procedure Manual - Excerpts (MSI)

Quarterly Meetings

The full group will meet quarterly in the middle of November, February, May and August to review the prior three months of work and outline the quarterly technical report. The meeting in mid-November will be at MSI's Yukon Plant.

By-Products

All team members would benefit from visiting the local production facility (Ebensburg Power Company) or off-loading location (Anker Energy Corporation and CONSOL Inc.). There is a limited amount of travel money in the budget which could cover this.

Graphics for Quarterly Technical Reports

A problem with all projects conducted by groups drawing from several organizations is incompatibility of word processors and graphics programs. Dr. Neufeld will control the central graphics for this project, using Quatropro. MSI and CHMR use Lotus, while DLC uses Excel. We think that Excel and Lotus are both convertible to Quatropro.

Levels of Detection

The concentration of eight metals from the toxicity characteristic list (As, Ba, Cd, Cr, Pb, Hg, Se and Ag) plus three of the new BDAT constituents (Cu, Ni and Zn) will be determined in the solid received samples (both the metal toxicity characteristic wastes received by MSI and the by-products received by DLC). Typically, any of the eleven that do not appear in solid received samples are not sought by MSI in the leachate. Silver (Ag) is almost always excluded on this basis. This metal may in fact be eliminated from the toxicity characteristics list in new RCRA regulations. Therefore, it was agreed that in leachates from the solid received samples and in the leachates from the products of treatment, the concentration of only those metals whose total solution would cause the leachates to exceed regulated levels will be measured.

The regulations that set the new BDAT standards, in addition to adding the constituents (for us Cu, Ni and Zn), have also added a new uniform treatment standard for wastes other than the metal toxicity characteristic wastes. This new standard reduces the allowable concentrations of seven of the eight metals (all but arsenic - As) significantly. In a lengthy discussion it was agreed that the tests used in this project should have detectability levels below the new uniform treatment standards. For six of the metals (Cd, Cr, Cu, Hg, Ni and Zn) flame will be sufficient. Flame may be sufficient for two others (As and Pb). However, three (Ba, Se and Ag) must be done by graphite furnace.

QA/QC Plan

The test plan should include a section on QA/QC. The QA/QC section will not present the full QA/QC plan, because the QA/QC plan is a separate document to be prepared by for October 18, 1994. Rather, the QA/QC section of the test plan should tell how the QA/QC plan will be prepared.

A quick perusal of Antech's QA/QC plan suggests that its method of "spiking" may be somewhat different from the absolute regulation. This possible variation needs to be examined carefully in preparing the project's QA/QC plan.

Fourth By-Product

Three by-products have been recommended by METC and PETC to replace the CZD material. The CZD process appears not to be moving toward commercialization.

Advanced Pressurized Fluid-Bed Combustion By-Product. A process development unit is operating at Livingston, NJ. A pilot plant is scheduled to start up in November 1995 at Wilsonville, AL. A commercial unit is planned for startup in 1998 at the Four Rivers Project. The by-product may contain CaS. It was agreed that this material, while of great interest to METC, does not meet the commercialization criterion for this project.

Pressurized Fluid-Bed Combustion By-Product. Operation of the unit at the Tidd Station is certain only until next spring. It likely will operate for another year after that, but beyond the extra year operation is quite uncertain. No U.S. commercial units have been ordered, although nearly a dozen are committed overseas. The sorbent at Tidd is dolomitic and the by-product has a relatively low pH, which makes it particularly attractive for arsenic stabilization. Further information on the availability of this by-product for this project will be sought. Ohio Power and all companies of American Electric Power Corporation in the past have denied any of their by-products for hazardous waste stabilization.

Gas Suspension Absorption By-Product. A ten-megawatt pilot plant at TVA's Shawnee Station has run successfully and is expected to continue in operation for the foreseeable future. Two fifty-megawatt commercial units are planned, one at the Shawnee Station at West Paducah, KY and the other at the Hamilton, OH municipal boiler. The latter project is funded by the Ohio Coal Development Office. Further information on the status of both commercial projects will be sought, along with the availability of the by-product to this project.

Ohio Edison. It was suggested that Ohio Edison be contacted for its advice on the selection of the fourth by-product to be examined in this project.

Pitt Group Meeting

The first meeting of the Pitt project team was scheduled for 9:00 a.m., Thursday, September 8, 1994 in Room 1139 of Benedum Hall.

RECORD OF MEETING SEPTEMBER 8, 1994 1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Ronald Neufeld, Emanuel Schreiber, Vourneen Clifford, and Jesse Pritts

Handed Out: Draft Test Plan - Phase 1 - September 7 Version

Test Plan for Phase 1

The principal new addition needed for the Test Plan for Phase 1 is a discussion of limits of detection. Dr. Cobb will work with Dr. Schreiber and Mr. Bender on this.

October 18 Deliverables

The Pitt portion of the Safety and Health Program will be developed by Dr. Schreiber with assistance from Ms. Clifford. The new Safety and Health Policy of the University of Pittsburgh will form its basis. The listing of ES&H Approvals and the Environmental Protection Plan will be derived from the Environmental Questionnaire. Dr. Schreiber, the project's QA/QC Coordinator, will also develop the QA/QC Program.

Laboratory Manual

The laboratory manual of the Pitt portion of the project will detail all procedures as performed in Pitt laboratories. An appendix will reproduce the printed version of the standard procedures from ASTM and EPA documents for guidance of those performing the tests. The Safety and Health Plan will also be appended to the laboratory manual.

Literature Survey

There will be two major elements to the literature survey. Production, properties, variability and utilization of by-products will be surveyed by Dr. Cobb and Ms. Clifford. Production, properties and current stabilization methods for hazardous wastes will be surveyed by Dr. Neufeld and Mr. Pritts. Assistance will be sought from Mr. Beeghly for the by-products survey and from Mr. Bender for the hazardous wastes survey.

Next Steps in the Laboratory

Ms. Clifford and Mr. Pritts will work with Dr. Schreiber to begin to become familiar with the laboratory procedures. Dr. Schreiber will begin to assemble the supplies needed to begin the laboratory work. Mr. Bender will be contacted to discuss providing several presamples to use to give the Pitt laboratory team some experience with this type of material.

By-Products

Dr. Cobb will work in particular with Mr. Beeghly to begin obtaining samples of by-products. It was suggested that visual views be obtained of the by-product production facilities and collection procedures for use in presentations.

Format of Data Tables for Final Report

It was suggested that a sketch be made of the data-containing appendices of the final report - one appendix, for example, for each of the up to 40 by-product/waste combinations. From this sketch the format of the data sheets for the laboratory work can be developed, along with the standard procedure to transfer the validated data into a computerized data base for analysis and production of tables for the final report. Dr. Cobb will format the final report and Dr. Neufeld will format the tables.

Regular Meeting Time

The Pitt group will meet every week at 10:00 a.m. on Thursday in Room 1139 BENDM unless a conflict arises. The Pittsburgh Coal Conference next week raises such a conflict, so the next meeting will be Thursday, September 22.

RECORD OF TELEPHONE CONVERSATION SEPTEMBER 19-22, 1994

Frank Hsu (Airpol)

Now that the Clean Coal Technology project has been completed, the U.S.DOE has taken full ownership of the pilot plant. TVA continues to operate it to collect design information for a 150 MW unit that they plan to install themselves. He recommended speaking with Thomas Burnett at TVA about the continuation of the project by that company.

The contract for the unit at Hamilton, Ohio, has been signed, but it will not be in operation for at least one-and-a-half years.

Thomas Burnett (TVA)

Mr. Burnett does not think there will be a problem with supplying the Airpol by-product to our project.

Steven Bossart (METC)

Mr. Bossart recommended speaking with Larry Rath and George Lee, both of METC, about the fourth by-product.

Carl Bender (MSI)

Mr. Bender favors the Tidd material because of its magnesium content.

RECORD OF MEETING
SEPTEMBER 22, 1994
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Ronald Neufeld, Emanuel Schreiber, Vourneen Clifford, and
Jesse Pritts

Requirements for October 18, 1994

Three program documents are to be available after October 18, 1994 in the laboratories of Pitt, Dravo Lime and Mill Service for inspection at any time by the Contracting Officer's Representative (COR) - Safety and Health Program, Environmental Protection Program and QA/QC Program.

Dr. Cobb will work with Dravo Lime and Mill Service to assure that the programs are available at those two organizations.

Ms. Clifford will work with Dr. Schreiber and Dr. Cobb to assemble the information for Pitt's Safety and Health Program. The document will contain appendices with Pitt's Safety Policy, Pitt's Chemical Hygiene Program and any safety guidelines contained in equipment manuals. The American Chemical Society's Working Safely in the Chemistry Laboratory contains much useful information.

Dr. Schreiber and Dr. Cobb will continue developing the QA/QC Program, using Dr. Schreiber's first draft as a basis and obtaining guidance from the programs of Antech and Dravo Lime.

Dr. Cobb will prepare a brief essay-style Environmental Protection Program based upon the Environmental Questionnaire. He will also develop the listing of ES&H Approvals that will be submitted to the COR on October 18, 1994.

Dr. Cobb will also speak to the COR about the formats of these documents.

Laboratory Activities

It is anticipated that the first sample for analysis will arrive at Pitt about mid-November. Ms. Clifford and Mr. Pritts will work with Dr. Schreiber to prepare a laboratory manual, including ASTM methodologies, and to assure that all methods are operating and that they are ready to run them.

Background Documentation

Mr. Pritts will begin work with Dr. Neufeld and Mr. Bender to review the current literature on hazardous waste stabilization and the general sources and properties of the hazardous wastes that are available to Mill Service. Ms. Clifford has located an excellent text on the first subject.

Ms. Clifford will begin work with Dr. Cobb and Mr. Beeghly to review the current literature on by-products from coal-fired boilers and the general sources and properties of the by-products that are available to Dravo Lime.

Dr. Neufeld has been collecting information on documents available from the International Energy Agency relating to by-products and their utilization.

By-Product Identification

Dr. Cobb and Dr. Neufeld will meet with Richard Chu of the Ohio Coal Development Office tomorrow on another project. They will ask him for his opinion on Airpol vs. Tidd as the source of the fourth by-product.

Format for Data Base

Dr. Cobb and Dr. Neufeld will begin to define the data that will be arriving from Dravo Lime and Mill Service and that will be generated by Pitt. Dr. Neufeld will then prepare a format for a computerized data base to contain this information.

Next Meeting Time

The next Pitt group meeting will be at 9:00 a.m. on Thursday, October 6, 1994 in Room 1139 BENDM.

RECORD OF TRIP TO PATRIOT MINING COMPANY, INC. NORTHERN WEST VIRGINIA JOEL BEEGHLY AND JAMES COBB VISITED RONALD HAMRICK AND DUANE MAUST SEPTEMBER 29, 1994

Three Patriot Mining Properties

Osage Mine - From Pittsburgh on I-79 take the Star City Exit. Turn right at the stop sign at the end of the exit ramp away from Morgantown onto Chaplain Hill Road. After this becomes gravel, go for 1.5 miles to a red gate on the right. The Patriot Mine office is to the right rear of the cluster of buildings. The property has one working pit and two pits being reclaimed. To date about 100K tons of by-product have been utilized on the site.

Stacks Run - Somewhere a few miles west of Kingwood The property has one underground mine, partially working, partially being reclaimed. On the surface is a by-product monofill, a refuse storage/sorting operation and a pit being reclaimed. A closed refuse fill is

also on the site. The portion of the underground mine being reclaimed is being reclaimed as one of the three PRDA projects from two years ago. It will be grouted through boreholes. To date about 500K tons of by-product have been disposed to or utilized on the site.

Albright Mine - From Pittsburgh on I-79 take I-68 east to Bruceton Mills Exit (Route 26). Follow Rt. 26 south to Albright. Cross the Cheat River on Rt. 26 and immediately turn right after going across the bridge. The mine is just around the bend on the left. Go up the slope to the buildings at the top of the property where the rail siding comes through a cut from the west. To date between 1M and 1.5M tons of by-product have been disposed to or utilized on the site. The rail car unloading facility has a full dust collection system. By-product is conveyed to a truck loader where it is wetted as it goes into the trucks for movement out onto the site.

Seven By-Product Sources

Three FBCs and two PC boilers provide by-product to the three Patriot mining sites:

AES Thames River Coal-Fired CFBC - Ash is loaded in hopper cars from the fly ash silo, from the bottom ash silo or from both. Ash may also be pelletized, although few pellets are currently produced, apparently because of problems with the pelletizer. Some water is sprayed on the upper surface of the ash in the cars for dust control, but most of the ash is dry underneath the crust. The cars are emptied from the bottom. They can be shaken to knock out any bridged material.

Cedar Bay (Florida) Coal-Fired CFBC - Using Kentucky coal, this plant is similar to the AES Thames Plant. Its pelletizer is not working either, so the by-product (which originally was to be returned to the mine in Kentucky) must be shipped to the Albright site where it can be unloaded with dust control which the mine in Kentucky lacks.

Morgantown Energy Project Coal- and Coal Refuse-Fired CFBC - Wet ash is trucked to the Osage and Stacks Run sites, dropped out the bottom of the trucks and spread by bulldozers. Sorted coal refuse from the Stacks Run site is burned in this boiler.

Fort Martin and Kingwood Coal-Fired PC Boilers - Ash has been used for over twenty years for soil amendment.

There are two other refuse-fired CFBC plants in the area. One is the American Power facility at Grant Town, ten miles southwest of Morgantown. Paul Stevens from that project has been in contact with METC, Dravo Lime and Pitt seeking to have Grant Town by-product tested in our project. The other plant in the area is located at CONSOL's North Branch Mine. We don't know anything more about this plant at this time, but we will learn more when we talk with CONSOL in two weeks.

Sampling By-Product at Albright

First, we need to identify what is in each hopper car, based upon its car number and what was placed in it at the AES Thames River Plant. The car can be sampled either as it empties from the bottom or after it has completed emptying and before the front loader begins to

transfer the pile to the conveyor belt. Dravo Lime will do the first sampling. Dravo Lime is scheduled to do the others but Patriot Mining Company may want to do them.

The plant's data on general properties of the ash (CaCO_3/CaO) and on the specific conditions under which material in each car was produced will have to be collected from the plant.

Reclaiming Projects at Patriot Mines

In general, the by-product is used to line the pits before overburden is replaced. After the overburden is in place, the fill is capped first with two inches of by-product, followed by two inches of top soil. The purpose of the by-product is to cut infiltration into the fill and to increase the pH of any water that does enter. The West Virginia Department of Environmental Protection was originally skeptical about using by-product in this way. However, the company has collected much performance information and the DEP has examined other properties as well. The DEP is now requiring utilization of ash at new sites. There may come a time when the mines in West Virginia may run out of by-product. West Virginia University is assisting the company in monitoring the water coming from the fills and in preparing reports on the various projects.

Soil Remineralization Projects

The U.S. Department of Energy, the U.S. Department of Agriculture and various state agencies, local authorities and private companies are studying the growth of trees and crops on land reclaimed using by-products. Ronald Korchak at USDA Beltsville MD and a group in Missouri are growing trees, Dale Ritchie at USDA Beckley WV is growing crops, Ohio State University is growing both trees and crops, and Alcosan in Allegheny County PA jointly with Waste Management/Wheelabrator is producing Biogrow, a growth medium containing sewage sludge. The Osage Mine has just received a permit to mix sewage sludge, ash and soil to grow trees.

Miscellaneous

Ken James is the new product/business development officer for Anker Mining Company.

A West Virginia company is making light-weight block from the by-product coming onto the Albright site. Duane Maust will provide a contact for us.

The "Ettringite" meeting at the University of Kentucky will be on November 2, 1994.

RECORD OF TELEPHONE CONVERSATION OCTOBER 3, 1994

Thomas Webb (AEP)

Mr. Webb is Manager, Waste Quality and Waste Management in the Environmental Engineering Division of AEP. He confirmed that it is currently the policy of AEP that ash not

be used in any remediations of CERCLA or Superfund sites. By extension this would include denial of Tidd by-product to our project.

RECORD OF MEETING
OCTOBER 6, 1994
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Emanuel Schreiber, Vourneen Clifford, and Jesse Pritts

By-Product Activities

On September 29, 1994 Mr. Beeghly and Dr. Cobb visited the Patriot Mining Company properties, including the Albright Mine where the ash from the AES Thames River Plant is unloaded and disposed. See the preceding trip report for details. They have an appointment at CONSOL's Research Laboratory in Library, PA on October 13, 1994 to discuss the spray drier material. They have an appointment at the Ebensburg Power Company on October 14, 1994.

According to Thomas Burnett of TVA, the Airpol material is available as the fourth by-product. We are still awaiting American Electric Power's answer on the availability of the Tidd material. Mr. Bender favors the Tidd material.

The Ohio Coal Development Office is interested in supporting beneficial use projects, but can spend money only in Ohio.

Ms. Clifford has obtained much information from Mr. Beeghly. She and Dr. Cobb have identified the major points that should be covered in the by-product review:

- properties of by-products
- variation in by-product properties
- production of by-products
- correlation of variation in by-product production with variation in by-products
- correlation of variation in by-products with treatment effectiveness

Hazardous Waste Activities

Mr. Pritts has obtained a listing of nine specific wastes from Mr. Bender that Mill Service expects to use in the project. He has also obtained much information from Mr. Bender about many of these sources, about the wastes themselves and about Mill Service's treatment methods.

Laboratory Procedures

Ms. Clifford and Mr. Pritts will meet this coming Monday, October 10, 1994 with Dr. Schreiber to begin developing the laboratory activities. Mr. Pritts has begun compiling the specific methods, which will be used in the project, from the ASTM volumes and the current version of SW-846 in the Bevier Engineering Library.

They have also made a good start on developing the Safety Program. Dr. Cobb will develop the Environmental, Safety and Health (ESH) List and the Environmental Program. He will also work with Dr. Schreiber on the QA/QC Manual. Only the ESH list needs to be sent to METC. The other three programs need only be available for inspection at Pitt by the COR.

Test Plan

Dr. Cobb continues to revise the test plan according to the comments received from the COR by letter on September 23, 1994.

Duplication

Dr. Cobb will set up a duplicating account in the Bevier Engineering Library for the project.

Next Meeting Time

The next Pitt group meeting will be at 9:00 a.m. on Thursday, October 13, 1994 in Room 1139 BENEDM.

RECORD OF MEETING OCTOBER 13, 1994 1132 BENEDUM ENGINEERING HALL

Present: James Cobb, Ronald Neufeld, Vourneen Clifford, and Jesse Pritts

Test Plan

A second letter, dated October 5, 1994 was received from Mr. Bossart, our COR, regarding the draft test plan. The response to both the September 23 and October 5 letters has been drafted and is being reviewed. Dr. Cobb will send it out and also make the changes in the draft test plan for transmittal to METC.

By-Product Activities

Mr. Bossart has given his approval to the three by-products, the ash from the AES Thames River Plant, the ash from the Ebensburg Power Company and the spray drier residue from the Chambers Works. In his letter of October 5 he added another by-product for consideration - the residue from the Tampella U-Gas Coal Gasification Process being pilot tested in Finland and scheduled for demonstration at the Toms River Plant. This by-product differs from the others being considered in that the ash spends a portion of its time in a reducing environment and another portion of its time in a zone with a temperature sufficiently high that the ash becomes tacky and agglomerates, thus producing hard, strong granules.

As noted at the meeting on October 6, 1994, Mr. Beeghly and Dr. Cobb have an appointment at CONSOL's Research Laboratory in Library, PA this afternoon to discuss the spray drier material. They have an appointment at the Ebensburg Power Company tomorrow.

Hazardous Waste Activities

Mr. Pritts has prepared a spread sheet with all of the waste properties which he obtained from Mr. Bender (see October 6 meeting record).

Laboratory Procedures

Ms. Clifford and Mr. Pritts will examine the curing room and compressive strength tester in SB-86.

They will prepare a specific work plan for each set of samples coming to Pitt from Mill Service.

They will develop a list of the initial materials needed for the experimental work at Pitt. They will conduct a trial run of all tests using a first trial set of samples from Mill Service.

Record Keeping

Dr. Neufeld will prepare a spread sheet in which to enter all laboratory results.

Everyone is advised to provide a date and identify the originator on all documents prepared for the project.

Next Meeting Time

The next Pitt group meeting will be at 9:00 a.m. on Thursday, October 20, 1994 in Room 1139 BENDM.

RECORD OF TELEPHONE CONVERSATION OCTOBER 13, 1994

Mario Marrocco (AEP)

Martin Meerhoff, an engineer in Mr. Marrocco's group, has received a letter from Thomas Webb which states that AEP's policy on providing its by-products to CERCLA and Superfund sites has been revised. The Tidd by-product is now available for a project such as ours and we are to make a formal request if we wish to use it. AEP will now support our project in this manner.

RECORD OF CONVERSATION OCTOBER 13, 1994

Larry Rath (METC)

Mr. Rath spoke to the Coal Technology Group of the Pittsburgh ACS Section at noon. I attended and spoke with him about the by-product from Tampella's UGas pilot plant in

Finland. He and Daniel Brdar, who was also at the luncheon from METC, recalled that the by-product from the KRW process was similar to the UGas by-product and was very granular. Not all the CaSO_4 in the KRW ash was reactive and a similar behavior would be expected for the UGas by-product.

RECORD OF TRIP TO CONSOL RESEARCH LABORATORY
LIBRARY, PENNSYLVANIA
JOEL BEEGHLY AND JAMES COBB VISITED FRANK THEODORE AND MILTON WU
OCTOBER 13, 1994

Carneys Point Cogeneration Plant

Mr. Theodore provided us with an article from Electrical World describing recent cogeneration plants, including Carneys Point, and a schematic of the facility. The spray drier at Carneys Point is the first one on a pulverized coal boiler burning high-sulfur eastern coal. Argonne and Ohio State both have spray driers on their stokers. Ohio State blends fly and bottom ash, while Argonne keeps them separate.

At Carneys Point air enters the bottom of the spray drier and all of the sulfur-capture residue rises through the upper port with the fly ash. The combined solids are captured in the baghouse and the baghouse residue is combined with the bottom ash from the boiler in a single silo. The combined material in the silo is about 50% ash and 50% sulfur-capture residue. The combined by-product contains 5-7% CaO. The moisture specification is 2% or less.

The boiler operates at a very stable load. If there is any problem with the system, the plant shifts to oil firing. The unit never operates with coal as a feed when the scrubber is not in operation. Thus, the combined by-product should be very consistent in its composition.

By-Product Placement

CONSOL owns the pneumatic cars that transport the by-product to the mine site near Waynesburg, Pennsylvania. At the mine the cars are unloaded pneumatically to a silo. From the silo the by-product is mixed with water in a pug mill, loaded into trucks and disposed onto the site.

By-Product Sampling

CONSOL will sample the by-product at the mine site. On three separate days (approximately two, four and six weeks hence) one sample each will be drawn from four cars. Mr. Theodore will work on obtaining car numbers, dates the by-product came from the silo at the plant and operating conditions of the plant at about the time of by-product production. Mr. Theodore will prepare a letter to the regional people operating the ash disposal site to arrange for the sampling.

Fourth By-Product

Mr. Theodore stated that of the three by-products currently being considered as the fourth one for this project, he prefers the Airpol material because it is the one most likely to be first commercialized.

Miscellaneous Comments

Mr. Beeghly mentioned that at many of the FBCs, which have been installed recently, systems have been included to place by-product both pneumatically and hydraulically into cars or trucks.

It was noted that dolomitic lime is used at the Tidd Station because it is both more porous (and thus more reactive) and easier to handle without bridging in the piping system through which it has to be transferred out of the unit.

RECORD OF TELEPHONE CONVERSATIONS OCTOBER 18, 1994

Steven Bossart (METC)

Mr. Bossart has reviewed the proposed changes to the first draft of the test plan and finds them all in order.

He agrees that the material from the U-Gas pilot plant in Finland should not be considered further for the fourth by-product. He is currently leaning toward the Tidd material because that will only be available for the next few months, whereas the Airpol material should be available almost continuously for the foreseeable future. Thus, the Airpol material can be examined in possible additional future projects. Mr. Bossart will call several members of the Airpol development team to clarify his thoughts about this material and will try to make the decision on the fourth by-product by early next week. Dr. Cobb noted that Mario Marrocco of American Electric Power reports that AEP has revised its policy on by-product use and AEP now will be pleased to support our project with material from the Tidd Station.

METC would like to hold the kick-off meeting for our project in mid-November. Five possible dates are November 9, 10, 14, 15 and 22, 1994. Representatives of Edison Electric Institute and the Grant Town Cogeneration Project have expressed an interest in attending. Mr. Bossart invited Dr. Cobb to attend the kick-off meeting of the new Radian by-product evaluation project on November 8, 1994.

Gary Anderson (EPC)

Mr. Beeghly and Dr. Cobb rescheduled their visit to the Ebensburg Power Company to Thursday afternoon, October 20, 1994. The plant will enter a scheduled outage early that week but should be back on line by then. Dr. Cobb is to check on Wednesday, October 19, 1994 to determine its status.

Joel Beeghly (DLC)

On October 17, 1994 Mr. Beeghly and Mr. Tutokey sampled one of two cars loaded with ash from the AES Thames River Plant. The sampled car was filled on September 21, 1994. The other was filled on September 25, 1994. They recorded the car number sampled and now we must contact the plant to learn how the boiler performed during that period.

Sampling was accomplished from the top of the car before it was moved into the unloading building. The crust was punched with a backhoe and a fly ash sample taken from below the crust. A large sample (two 5-gallon buckets) was drawn. Dravo Lime will split out a small sample for Pitt and a larger one for Mill Service.

They determined that there was no way to obtain a good sample of the material during or after unloading. There is a large pit underneath the unloading point. A conveyor draws by-product from the pit to the truck loader. Two backhoes assist in unloading. One breaks up bridges in the pit. The other breaks up bridges in the car that aren't dislodged by the shaker.

They learned that there are two boilers at AES Thames River Plant. One of them is down for a while.

RECORD OF MEETING OCTOBER 20, 1994 1248 BENEDUM ENGINEERING HALL

Present: James Cobb, Ronald Neufeld, Vourneen Clifford, and Jesse Pritts

Test Plan

Dr. Cobb has prepared the second draft of the test plan and will distribute it soon. He reported on Mr. Bossart's acceptance of the test plan changes on October 17, 1994.

By-Product Activities

Mr. Bossart's views of October 17, 1994 on the fourth by-product were mentioned.

Ms. Clifford distributed the first portion of a report on by-products last Friday, October 14, 1994. Dr. Neufeld will provide modifications to the section on leaching. He noted in particular the need for extensive descriptions of the processes generating the by-products. Dr. Cobb reported on the visit he and Mr. Beeghly made to CONSOL on October 13, 1994 and gave Ms. Clifford a copy of the article from Electricity World and the flowsheet of the Carneys Point Plant. Dr. Neufeld noted that he can enter diagrams such as the flowsheet into the computer to use in producing reports and slides.

Mr. Beeghly and Dr. Cobb will visit the Ebensburg Power Company this afternoon. They will also contact the AES Thames River Plant to obtain information about the facility and about its operation during sampling periods. Mr. Beeghly obtained a first sample from the Albright Mine on Monday, October 17, 1994.

Hazardous Waste Activities

Mr. Pritts continues to write up background he received from Mr. Bender on the nine wastes that Mill Service expects to treat with our by-products.

Laboratory Procedures

Dr. Neufeld noted that the ASTM leaching test calls for a 4:1::water:material ratio as compared with the TCLP leaching test, which calls for a 20:1::water:material ratio. We need to talk to Mr. Bender about the correspondence of the ASTM and TCLP tests, their respective protocols and their relation to present and future regulations.

Kick-off Meeting

We are considering Thursday, November 10, 1994 to hold the project's kick-off meeting at METC. Edison Electric Institute and the Grant Town Cogeneration Plant are both interested in having representatives attend. Dr. Neufeld suggested that Mr. Chu of the Ohio Coal Development Office be invited also.

Next Meeting Time

The next Pitt group meeting will be at 9:00 a.m. on Thursday, October 27, 1994 in Room 1139 BENDM.

RECORD OF TRIP TO EBENSBURG POWER COMPANY
EBENSBURG, PENNSYLVANIA
JOEL BEEGHLY, JAMES COBB AND STEVEN TUTOKEY VISITED
GARY ANDERSON AND DANIEL MATTINGLY
OCTOBER 20, 1994

Power Plant Description

Mr. Anderson provided a 1993 six-page EPRI brochure and a 1993 two-page B&W flier containing information about the plant. Both contain a color aerial photograph and a side-view schematic of the boiler. [Note that a second CFBC of Pyropower design, operated by Air Products, is also located in Ebensburg.] Following the air heater, the fly ash is removed in a ten-segment baghouse and conveyed to the silo. Approximately 70% of the by-product in the silo is baghouse ash; 30% is bottom ash. The bottom ash is at about 350°F when it exits the ash cooler below the boiler. Mr. Anderson will send us any other documents he can find about the plant, its design and operation.

The coal waste fed to the boiler has a sulfur content between 1.4 and 2.0 percent. The limestone is 83% CaCO_3 . It is sized at 12 mesh x 0 and contains between 5 and 10 percent through 140 mesh. Mr. Anderson gave Mr. Beeghly a copy of a limestone analysis. He will send us any information he can find about the measured properties of the ash.

Sampling

Mr. Beeghly and Dr. Cobb described the hazardous waste treatment project and the analyses that Dravo Lime will perform on the by-product.

It was agreed that ten samples would be drawn from the line connected about halfway down the bottom cone of the ash silo and analyzed within the scope of the project. In addition, several samples of fly ash (a combined sample from three of the baghouse hoppers) and several samples of bottom ash would also be taken and analyzed outside the scope of the project.

The samples from the silo will be drawn in the morning when the by-product in the silo is at its daily maximum depth. The silo is gradually drained to near empty by mid-afternoon. The power plant's operation is essentially base-loaded and very stable. A printout of the plant's operating parameters at the time the sample is drawn will be provided in an envelope attached to the sample bucket(s).

Mr. Mattingly will draw a first set of samples for us on Monday, October 24, 1994. We left three plastic 5-gallon buckets for him to fill from the silo. He will also draw a fly ash sample and a bottom ash sample. Mr. Tutokey will come to the plant that day to pick up the filled buckets.

Strength of Placed By-Product

The operators of the refuse site near Revloc, Pennsylvania, where the by-product is now being placed, may have information on the strength achieved by the by-product when mixed with moisture and aged on the fill.

RECORD OF TELEPHONE CONVERSATIONS OCTOBER 21, 1994

Mark Boucher (AES Thames River Plant)

Mr. Boucher is the Electrical and Pelletizing Superintendent for the plant. The AES Thames River Plant is near Groton and New London, Connecticut, about one hour east of New Haven. About six months ago, JTM, a subsidiary of the Union Pacific Railroad, obtained a contract to manage all of the by-product of the plant. JTM has negotiated a contract to shift the by-product from the Albright Mine to the very dramatic Porter site near Good Spring, Pennsylvania, where it will be used for soil amendment for anthracite culm reclamation. [Good Spring is on PA 125 about three miles northwest of Exit 33 of I-81 at its junction with US 209.] Mr. Boucher suggested talking with Thomas King of Energy Resources and Logistics, Inc., a subsidiary of CSX in Jacksonville, Florida, who is close to the contract negotiations.

Joel Beeghly (DLC)

He has worked with JTM before and knows a lot about them. JTM brokers the by-product from the boiler at GM in Pontiac. Before beginning to sell this by-product through JTM, GM used it to treat chrome-laden wastes at Pontiac. JTM may be selling some for waste stabilization, but, if so, GM forbids having its name associated with this material. Mr. Beeghly has been there frequently to advise on details of utilization.

Mr. Beeghly reported that JTM is active in the American Coal Ash Association. Grover Dobbins of JTM is a member of the ACAA executive board. JTM brokers Magnalime from the Ashland Oil refinery at Catlettsburg, Kentucky, some of which has been used for stabilization of sludges at the American Cyanamid plant at Parkersburg, West Virginia. Thus, JTM should know much about the use of by-product in general for hazardous waste treatment and may have suggestions for us that will be useful in this project.

He also recalled that JTM may be working with the Enviro people in New Jersey on sewage sludge stabilization. They also may be studying flowable fill in Pennsylvania and lightweight block in Massachusetts. Mr. Beeghly works closely with the JTM representative for the upper midwest, who works out of Dayton, Ohio and has met the JTM representative for Pennsylvania.

Thomas King (Energy Resources and Logistics, Inc.)

He expressed great surprise upon learning the details of our project, the role of the by-product from the AES Thames River Plant and especially the fact that we obtained a first sample on October 17, 1994. He noted that the offer from Anker Energy of samples of the by-product was valid when made in July 1993. However, the shifting contractual arrangements, which started developing this past spring and have another month or two before settling into a new alignment, now require a thorough discussion among the partners to the new contracts. In particular, JTM has assumed much more central role and is a major national broker of by-product. For example, it brokers all of the ash produced by American Electric Power, which leads to some question about the Tidd material as well. Mr. King identified Howard Humphrey as the ash manager for AEP. Mr. King suggested talking with Grover Dobbins of JTM, who is the principal contact for the new contractual arrangements at JTM's Kennesaw, Georgia headquarters, just to the northwest of Atlanta.

RECORD OF TELEPHONE CONVERSATIONS
OCTOBER 26, 1994

Steven Bossart (METC)

The kick-off meeting is set for November 10, 1994 from 2:00 to 4:00 p.m. Dr. Cobb is to prepare an agenda and send it to Mr. Bossart.

The fourth by-product will be the Tidd material. The demonstration unit at the Tidd Station is assured to be operating only through February 1995, so it needs to be sampled completely for both Phase One and Phase Two by then. The Airpol by-product should be available

regularly for a number of years and can always be included as a fifth by-product at a later time by a contract augmentation or a new contract.

Dr. Cobb reported on the by-product collections to date.

Mr. Bossart will invite outside attendees to the kick-off meeting from Grant Town, EEI, OCDO and ACAA. Dr. Cobb will invite the four by-product producers.

Grover Dobbins (JTM)

Mr. Dobbins is the on-site manager for the brokerage of the by-product from the AES Thames River Plant. He indicated that it is most appropriate for us to obtain the concurrence of the plant operators for the continued use of their material in our project once it shifts to the Porter site. JTM will endorse any use in which the plant concurs. He noted that CSX had conducted the negotiations that shifted the by-product from Albright to Porter.

Kenneth James (Anker Energy Company)

The letter of commitment which Mr. James provided to the project in late July 1993 was prepared by Anker Energy without consultation with the AES Thames River plant because the material becomes the property of Anker Energy when it enters the Albright site. He expects by-product to arrive from Thames River at least through December 31, 1994 and likely well into January. He suggests trying to take all ten Phase One samples by December 31, 1994 for convenience. He noted that he had sent some of the fly ash from Thames River to Mill Service several years ago and that after testing it Mill Service declined to use it commercially. He will send information from his files on this.

RECORD OF MEETING OCTOBER 27, 1994 1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Emanuel Schreiber, Vourneen Clifford, and Jesse Pritts

Supplies

Ms. Clifford and Mr. Pritts are working with Dr. Schreiber to order a variety of supplies. The Civil and Environmental Engineering subaccount will be used on the requisitions.

By-Products

The Tidd by-product will be the fourth one for the project. It was selected because its availability will cease early next year. All samples for both Phase One and Phase Two must be acquired by then. The Airpol material should be regularly available commercially over the coming years. It can be examined in an extension of the current contract or in a new one.

Mr. Beeghly will be working to obtain samples from Albright, CONSOL and Ebensburg as soon as possible and send portions to Mill Service and Pitt. Hopefully, a first sample of treated waste can arrive at Pitt by November 14, 1994.

Additional articles on by-products have come from Dr. Cobb and Mr. Beeghly. Ms. Clifford has begun placing them by category in hanging files in a drawer in Room 965. Ms. Clifford will continue to expand the bibliography on by-products.

Dr. Cobb returned a marked-up copy of her paper on "Characterization of Advanced Clean Coal Technology By-Products" to Ms. Clifford. She will continue to augment it, especially with new material from Ebensburg and Tidd.

Laboratory Work

Ms. Clifford and Mr. Pritts established a schedule for laboratory work with Dr. Schreiber. Both students are unavailable on Thursdays this term. Mondays, Tuesdays, and Fridays appear open. Dr. Schreiber's schedule varies from week-to-week but Thursday afternoon is his only regular class meeting. Close cooperative work will begin at 10:00 a.m. on Monday, October 31, 1994.

A detailed discussion of protocols, QA/QC methods (including chain of custody) and datakeeping ensued. Ms. Clifford and Mr. Pritts will be responsible for recordkeeping and QA/QC on the project. Dr. Schreiber will advise them on proper procedures.

Dr. Cobb will work with Mr. Bender to stage the samples coming to Pitt so that a reasonably even flow of effort is required and maintained.

Meetings

Mr. Pritts will be able to attend the kick-off meeting on November 10, 1994. Presentations at the meeting will be given by Dr. Cobb, Mr. Beeghly, Mr. Bender and Dr. Neufeld.

Dr. Cobb will attend the workshop on "Mineralogical/Chemical Transformation in Coal By-Products" at the Department of Mines and Minerals Building of the University of Kentucky in Lexington on Wednesday, November 2, 1994. He will also attend the kick-off meeting for Radian's project on "Monitoring of Field test Cells Containing Coal By-Products" on Tuesday morning, November 8, 1994 at METC. Radian will also discuss its approach to commercialize technology.

Next Meeting Time

The next Pitt group meeting will be at 9:00 a.m. on Thursday, November 3, 1994 in Room 1139 BENDM. Dr. Neufeld will chair the meeting in Dr. Cobb's absence. The meeting after that one will be at 9:00 a.m. on Thursday, November 10, 1994 in Room 1139 BENDM.

RECORD OF TELEPHONE CONVERSATIONS
OCTOBER 28, 1994

Joel Beeghly (DLC)

Mr. Tutokey is at Ebensburg today to pick up the first large combined sample and two small samples of bottom ash and fly ash. He will go to Albright for another sample next week while Mr. Beeghly is in Kentucky and Ohio.

Dr. Cobb reported that the fourth by-product will be from Tidd. Mr. Beeghly has just brought back a small 10-gallon sample from Tidd. The PFBC has been shutdown until Thanksgiving.

Mr. Beeghly will try to obtain one or more samples from Albright on the morning of November 10, 1994 before the kick-off meeting. The shifting of by-product from the AES Thames River Plant from Albright to Porter means that we need car numbers as soon as possible to get all samples for Phase One by early next year.

Carl Bender (MSI)

Dr. Cobb reported that the fourth by-product will be from Tidd.

Mr. Bender stated that Dravo Lime Company should deliver all by-product samples to Ms. Carol Kiselich at the Yukon Plant. Her telephone number is 722-3500.

The earlier by-product sample from Albright was tested for its ability to neutralize waste acids (liquids). It was not tested as a treatment chemical for solid wastes.

In the news release, the reference to the Bulger Plant should be removed. That site ceased operation seven or eight years ago.

Mill Service has held some discussions in the past with JTM.

RECORD OF TELEPHONE CONVERSATIONS
NOVEMBER 7, 1994

Mark Boucher (AES Thames River Plant)

The AES Thames River Plant cannot give its approval of the use of its by-product for our project until it has indemnification from CSX. I am to call Mr. King at (904) 366-5351 to discuss submitting a proposal to CSX asking for permission to use this by-product. The proposal should be comprehensive as to the benefits of the project, its basic approach and the disposal of treated wastes from it. Comprehensiveness will reduce the possibility of time wasting telephone conversations for clarification.

The AES Thames River Plant is base-loaded, operating at 95-96 percent of capacity constantly. It generally has two scheduled outages each year and experiences only one or two unplanned ones per year. It has a very high availability. Thus, ash from it should have a very high probability of coming from a steady-state period.

Joel Beeghly (DLC)

Mr. Beeghly will continue to sample the fly ash from the AES Thames River Plant at Albright as rapidly as possible, even though we do not have car numbers, dates of collection or assurances of steady-state operations. Dr. Cobb will prepare the proposal to CSX as rapidly as possible in order to draw as many samples as possible with prior operational knowledge.

Mr. Beeghly will prepare four or five viewgraphs for Thursday's kick-off meeting and will make hard copies for distribution.

Mill Service now says it needs more than one bucket of material for a large sample. Dr. Cobb will speak with Mr. Bender about this so that Mr. Beeghly can draw a sufficient amount to provide to Mill Service.

RECORD OF TELEPHONE CONVERSATIONS
NOVEMBER 9, 1994

Thomas W. King (Energy Resources and Logistics, Inc.)

AES Thames River Plant has, and always has had, complete authority over the disposition of its by-product. Anker Energy is, and always has been, without authority to provide our project with that material.

The contractual relationships in the management of the by-product is shifting. JTM was previously one of several brokers allowed to seek disposition for the material. When the new contracts are in place early next year, JTM will be the sole broker. JTM has used CSX in the past and, as far as the material now going to Anker Energy and soon to go to the Porter site is concerned, CSX will continue to transport it. In fact, CSX is the point of contact for approval to use the by-product from the AES Thames River Plant, going to the Albright Mine and soon to the Porter site, for treatment of hazardous waste.

Mr. King recommended that a proposal be sent to him, providing a detailed outline of the nature, methodology, location and participants of the project and requesting approval for its use in our work. He would pass it back to JTM and they in turn to AES Thames River for approval. It would then have to be added as an annex to the JTM contract in which several investment banks have financial involvement.

Thomas Burnett (TVA)

Mr. Burnett left a message with the secretary of the Center for Energy Research that he has collected a 5-gallon sample of the GSA material, which we are welcome to have.

RECORD OF MEETING
NOVEMBER 10, 1994
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Ronald Neufeld, Vourneen Clifford and Jesse Pritts

By-Products

Dr. Cobb reported on the workshop on "Mineralogical/Chemical Transformations in Coal By-Products," which he attended at the University of Kentucky on November 2, 1994 and on the Kick-Off Meeting for the Radian Corporation's next contract on "Advanced Coal Technology By-products - Management, Reuse and Disposal" which he attended at the Morgantown Energy Technology Center on November 8, 1994.

The workshop included presentations from the groups at Ohio State University, Iowa State University, Penn State University, Consol, Radian, University of North Dakota, North Dakota State University, University of Kentucky and Stevens Institute of Technology. No notes were distributed at the workshop, although one reprint of work at North Dakota State University was provided. Dr. Cobb took extensive notes throughout the day.

The Radian Kick-Off Meeting contained four sections: (1) review of work on their prior ten-year contract in which they constructed and observed several test cells with advanced clean coal technology by-products, (2) overview of their new two-year contract which is essentially a new set of tasks associated with the previous test cells, (3) review of Radian's new thrust into technology development and hardware manufacturing, in which they seek to contribute to their clients' profitability and quality goals, and (4) review (by Mr. Bossart) of the overall by-product characterization and utilization program at METC and across DOE. Radian provided copies of the viewgraphs of the first and third sessions and METC provided a copy of the fourth one. Dr. Cobb took extensive notes throughout the presentations.

Copies of several of the documents obtained at the two meetings were distributed to the group. It should be noted that attendees lists were developed at both meetings. Also, Robert Bedick reported that a report to Congress by DOE on "Barriers to the Increased Utilization of Coal Combustion/Desulfurization Byproducts by Governmental and Commercial Sectors" has just been released. He promised to send a copy to Dr. Cobb.

It is clear from these two meetings that two principal areas require considerable new work: (1) mineralogical studies of fresh by-product and stabilized waste products, and (2) experiments directed toward understanding if and by what means metals are incorporated into the final crystal structure of the stabilized/solidified waste. Professor Jean Blachere of the Materials Science and Engineering Department can provide much assistance in both of these areas.

Laboratory Work

Ms. Clifford and Mr. Pritts have moved from Room 965 BENDM to Room 976 BENDM in order to be closer to the equipment which they will be using for much of their work on the project. They have begun some tests using fly ash and cement from the light-weight concrete study

that Dr. Neufeld is conducting. The tests include TCLP and ASTM digestions and analyses of the extracts. They are also testing blank and spiked samples. This is the opening part of the QA/QC portion of their work. Dr. Cobb provided them with a copy of Dr. Schreiber's draft of the QA/QC program to serve as the basis for a final version to be included with the project laboratory manual.

Mr. Pritts has examined the equipment and materials in Room SB-86 BENDM for testing the cylinders of stabilized/solidified wastes that will be produced by Mill Service.

Meeting at Mill Service

The project team should hold a meeting at the Yukon plant of Mill Service at its earliest convenience. Dr. Cobb will speak with Mr. Bender at the Kick-Off Meeting this afternoon about a visit.

Next Meeting Times

The next Pitt group meeting will be at 9:00 a.m. on Thursday, December 1, 1994 in Room 1139 BENDM.

RECORD OF KICK-OFF MEETING NOVEMBER 10, 1994

The Kick-Off Meeting for our project on "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products" on November 10, 1994 at METC was excellent. Everyone is to be thanked for their contributions to the overall activity and to the meeting in particular. Attending from our project team were Joel Beeghly, Carl Bender, James Cobb, Ronald Neufeld, Jesse Pritts and Steven Tutokey. Attending from METC were Mary Beth Ashbaugh, Robert Bedick, Steven Bossart and Vijay Kalkari. Other attendees were:

Susanne Buckley
American Electric Power Corporation
(614) 223-1265

Richard S. Chu
Ohio Coal Development Office
(614) 466-6538

James Roewer
Edison Electric Institute
(202) 508-5645

Copies of the handouts from Pitt, Dravo Lime and Mill Service accompany the copies of this memorandum for Ms. Clifford, Dr. Schreiber and Audrey Zelanko, who could not attend the meeting.

Dr. Cobb felt that the highlight of the meeting was the detailed description of the operation of a hazardous waste treatment facility that Mr. Bender shared with the group. This likely was the first time the others in the room had ever focussed upon the careful procedures used by firms such as Mill Service to properly treat and dispose hazardous wastes. As a result, AEP, EEI, OCDO and METC should be much more comfortable about this beneficial use for their by-products, which it is hoped that they will share with their colleagues and associates.

Here are some thoughts that Dr. Cobb jotted down as the discussion went along. Some of them are based upon his recent attendance at the "Ettringite" Meeting in Kentucky (November 2) and the kick-off meeting at METC for Radian's new project (November 8).

- Mr. Bossart expressed concern for possible stratification of material in the rail cars coming from the AES Thames River Plant. He recommends obtaining a well-collected sample directly from the plant to compare with the samples from the cars.
- Mr. Beeghly passed around the table a number of samples of by-product already collected. He also sent around a cylinder made from Tidd bottom ash in a Procter mold. We need to talk further in our group about the amount of waste to use to make our cylinders. The higher the amount needed to achieve a two-inch slump will result in lower strengths.
- Mr. Beeghly has obtained the MSDS for the Tidd ash. Are MSDSs available for the other three by-products?
- The Tidd "cyclone ash" has 2-3% baghouse ash in it.
- Mr. Bossart approved collecting the Phase Two sample from Tidd before it ceases operation in February 1995.
- The first of the large samples for each by-product will be sized such that it will provide all the material that Mill Service requires for Phase One. We need to work out again exactly how much that should be.
- Mill Service does not handle mercury-containing wastes. It does, however, treat two listed wastes - K062 and F039. It also treats some residual (non-hazardous) wastes. (See next bullet.)
- In examining page four of Mill Service's handout, it is apparent that simply removing hazardous characteristics may not fully prepare the material for landfill. Conversely, non-hazardous waste may not be permissibly landfilled because of its properties once placed. Additionally, some non-hazardous material can become hazardous when treated because amphoteric components resolubilize at high pH. We need to go over all this at some point.
- It was noted that, to carry out routine laboratory-scale treatability studies, Mill Service requires only one gallon (10 pounds) of waste.

- No "industry standard" exists on how to conduct a treatability study at bench scale to determine the treatment recipe.
- Some treatments require other chemical additives besides lime. What is the role, if any, of these additives in our project?
- The properties of sandblast wastes and contaminated soils vary from batch to batch. Mill Service will screen these waste streams to assure representative samples for our study.
- Mr. Kalkari pointed out that the soil characteristics of contaminated soils may also vary from source to source. Solidification parameters may be quite dependent upon soil type. This needs to be addressed in our selection of contaminated soils for treatment. We should check with Mr. Bossart about this.
- AEP has begun taking more "risk" as it decides on beneficial uses for its by-products. It recognized that rises in by-product prices can cover more "risk" in use.
- EEI's representative asked about "LDRs" (sic) and their effect on solidification. He also expressed strong interest in the indemnification issue and would be happy to enter into further discussion on this subject.
- Advanced Technology Systems has just received a contract to sample by-products around the country. They will distribute them to UNDEERC and Iowa State for analysis.
- The DOE "Barriers to Utilization" report to Congress is now publicly available. Mr. Bossart will send a copy to Pitt.

At the conclusion of the meeting, the Pitt contingent agreed to meet with Mr. Bender and Ms. Kiselich (manager of the on-site laboratory at Yukon) at the Yukon Plant at 1:30 p.m. on Monday, November 21, 1994 to discuss pertinent details of analysis and to coordinate the transfer of samples from Mill Service to Pitt. Representatives of Dravo Lime and CHMR are welcome to participate.

APPENDIX B

BY-PRODUCT REVIEW

CHARACTERIZATION OF ADVANCED CLEAN COAL TECHNOLOGY BY-PRODUCTS

Vourneen Clifford
Center for Energy Research
University of Pittsburgh

ABSTRACT

The 1990 amendments to the Clean Air Act have spurred the development of Clean Coal Technology (CCT) processes, most of which produce a dry, solid by-product material consisting of excess sorbent, reaction products containing sulfates and sulfites, and coal fly ash. Presently, most of the dry combustion/desulfurization by-product materials are treated as solid wastes and must be landfilled. It is, therefore, highly desirable to find beneficial reuses for these materials provided the environmental impacts are minimal and socially acceptable. One potential opportunity for utilization of the mass quantities of CCT by-products that are being produced is the stabilization and solidification of metal-laden hazardous wastes. In order to explore the feasibility of the utilization of dry combustion/desulfurization by-products for the stabilization and solidification of metal-laden hazardous wastes, the chemical, mineralogical, physical, and leaching properties of the by-products need to be well defined so as to enable further study of their interactions with toxic metals. The objective of this paper is to characterize these selected critical properties of typical advanced CCT by-products that are representative of the actual by-products that will be used in the "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products" research project. A literature review of previous reports of by-product characterization obtained from various clean coal technologies has yielded the resulting representative characterization of the chemical, mineralogical, physical, and leaching properties described in the text of this paper. A survey of descriptions of the types of power plants producing the four by-products used in this study provides insights into the origin of these properties and variations in them. The information presented here will hopefully lead to the eventual identification and commercial application of beneficial uses of advanced clean coal technology by-products.

LIST OF FIGURES AND TABLES

Figures

1	Circulating FBC Process Showing Residue Sources	52
2	Pressurized FBC Process Showing Residue Sources	52
3	The Spray Dry Scrubber Process	53

Tables

1	Typical Percent Specifications For Examples of "F Ash"	54
2	Total Oxide Compound Analysis of Typical Fly Ash	55
3	Typical Operating Parameters of a 20 MW FBC Pilot Plant	56
4	Typical Analysis of the Waste Streams from TVA's 20MW Pilot Plant	57
5	Mineralogical Compositions of Typical Dry CCT By-Products (wt%)	57
6	Physical Properties of Selected Dry Sulfur Sorption By-Products	57
7	Comparison of Water and Acid TCLP Leachates From Representative Dry Sulfur Sorption By-Products	60
8	Leaching of Toxic Metals in Portland Cement and "F Fly Ash"	61

INTRODUCTION

The Clean Coal Technology (CCT) Program is a cooperative effort, cofunded by government and industry, to demonstrate a new generation of innovative coal processes, which are environmentally cleaner and more efficient than conventional coal-burning processes.¹ In dry CCT systems, a calcium-based sorbent (usually slaked lime, limestone, or dolomite) is injected directly into a furnace, ductwork, precipitator, or scrubber vessel that produces powdered or granular by-products, as opposed to the slurries associated with traditional wet scrubber systems. The specific composition of a particular type of by-product may vary widely depending upon the CCT process employed, the coal and sorbent composition, and the plant operating conditions. Since the chemical, physical, and engineering properties of dry CCT by-products are directly related to their mineralogy, it is essential to accurately determine the mineralogical composition of these wastes if safe and economical uses are to be defined. Vast quantities of dry CCT wastes may be produced in the near future and it is important that beneficial uses be developed to reduce landfill demands.²

In dry sulfur sorption systems the sorbent is injected directly into the furnace, into the ductwork after the furnace at lower temperature, or into a spray dryer vessel. All these processes produce a by-product which is removed in the particulate control equipment. Dry by-products from lime or limestone injected into the furnace, such as in FBC systems, have neutralizing, sorptive, and cementitious properties that make them particularly interesting as potential reagents for hazardous waste stabilization because of their high free quicklime (CaO) and anhydrous calcium sulfate (CaSO_4) contents.

The objective of this paper is to review the chemical, mineralogical, physical, and leaching properties that are typical to CCT by-products in order to determine their usefulness in the treatment of metal-laden hazardous wastes. Four advanced clean coal technology combustion/desulfurization by-products have been identified for use in laboratory studies and for potential use in field studies of the stabilization/solidification of metal-laden solid hazardous wastes. The sources of the by-products identified for this study are described below.

SOURCES

Residue from a Coal-Fired Circulating Fluid Bed Combustor (CFBC), supplied by Anker Energy Corporation. This material is produced by the cogeneration project of Applied Energy Service at its Thames River Plant near Uncasville, Connecticut. Anker Energy Corporation supplies the coal used in the plant and must backhaul the residue to its mines in West Virginia. Some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from Connecticut to West Virginia. The residue is estimated to contain 45% limestone equivalent, 28% ash and 27% $\text{CaSO}_3/\text{CaSO}_4$. It is relatively coarse material, as it contains both bottom and fly ash from the boiler.³

Dry Scrubber Residue, supplied by CONSOL, Inc. from a Joy Niro Spray Dryer. This material is produced by the cogeneration project of Chambers Cogeneration Limited Partnership, operated by U.S. Operating Services Company on the grounds of DuPont's Chambers Works in New Jersey. CONSOL, Inc. supplies the coal used in the plant and has agreed to backhaul the residue to its mines in western Pennsylvania and West Virginia. Some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from New Jersey to western Pennsylvania and West Virginia. The residue contains 45% fly ash, 36% $\text{CaSO}_3/\text{CaSO}_4$, 10% $\text{Ca}(\text{OH})_2$, 2% CaCO_3 , and 7% other inert material. It is comprised of agglomerates of fine materials, formed in the scrubber.³

Residue from a Coal-Waste-Fired CFBC operated by the Ebensburg Power Company. Approximately 200,000 tons/year of this material is produced in an operating unit at Ebensburg, Pennsylvania. Currently it is being trucked back to the mines from which the coal wastes are derived. Some or all of this by-product could be diverted to nearby sites for beneficial use if they could be identified. The residue contains 82% ash, 12.5% limestone equivalent and 5.5% $\text{CaSO}_3/\text{CaSO}_4$. It is relatively coarse material, as it contains both bottom and fly ash from the boiler.³

Residue from a Coal-Fired Pressurized Fluid Bed Combustor (PFBC), supplied by the Tidd Station of Ohio Power Company, a subsidiary of American Electric Power Corporation, at Brilliant, OH. This demonstration facility was constructed and is operated in cooperation with the U.S. Department of Energy in Round 1 of the

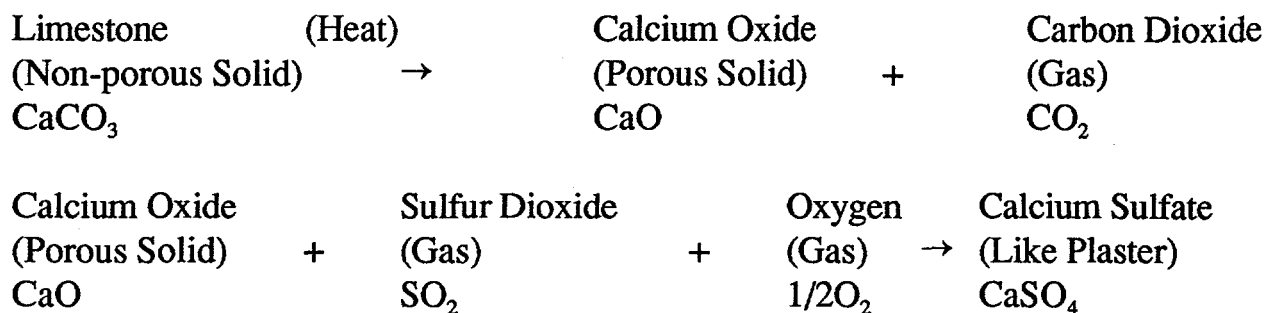
Clean Coal Technology Program. This large prototype facility is the first full-scale demonstration of the pressurized fluidized bed combustion (PFBC) process in the U.S. The Babcock & Wilcox design unit has a gross electrical output of 74 MW. Pittsburgh #8 coal is burned with dolomite as the sorbent, rather than lime or limestone, at a calcium to sulfur molar ratio of 1.6:1. Sulfur removal efficiencies of 90% or better are anticipated along with NO_x emissions that meet federal standards. By operating at high pressure, little of the dolomite in the residue is in the oxide form, most is present as carbonate. Three flue gas desulfurization (FGD) by-products, totaling approximately 22 tons per hour, are produced in the PFBC process: bed ash, cyclone ash, and precipitator ash.^{5,6} Thus, the residue may be obtained as bottom ash, fly ash, or a mixture. The dolomitic character of the sorbent yields a residue that is lower in pH than that produced from lime-based sorbents. This characteristic is particularly useful in stabilizing arsenic-laden waste solids.³ According to Dravo Lime, the chemical composition of the residue is 50-60% equivalent CaCO₃ and 1-2% available (free or uncombined) CaO.

CLEAN COAL TECHNOLOGY PROCESSES

Fluidized Bed Combustors

Fluidized bed combustion (FBC) is a process of burning crushed coal in a bed of limestone particles held in suspension by the upward flow of combustion air entering a chamber through a perforated air distribution grid below the fluidized bed. Lime is specifically calcium oxide (CaO) and usually contains varying amounts of other alkaline products in small amounts such as sodium and magnesium oxides as well as calcium carbonate. Commercial chemical grade hydrated lime contains over 92% calcium hydroxide or calcium oxide.⁷ Crushed limestone is first placed in the bed on the air distribution grid. The bed is then fluidized by injecting air through the grid to form an expanded, suspended mass closely resembling a boiling liquid, hence the name "fluidized." Oil burners are used to heat the bed material to the coal ignition temperature, and then coal feed is started.⁷ During operation, coal and limestone are fed continuously into the bed. The tumbling motion of the coal enhances the burning process. Combustion temperatures are held to around 1,400 to 1,600 °F, or almost half the temperature of a conventional boiler.¹

As the coal burns, sulfur is released as sulfur dioxide. The limestone reacts with the sulfur dioxide and prevents the sulfur dioxide from escaping into the atmosphere. The chemical process is as follows:



The limestone acts like a chemical "sponge" to capture the sulfur before it can escape the boiler. More than 90% of the sulfur released from coal can be caught in this manner. The sulfur-laden limestone and the ash from the coal form a dry waste product. Larger particles of coal ash and spent limestone are drained from the bottom of the bed. The smaller ash and spent limestone particles, or "fly ash", are carried out of the boiler and captured with dust collectors. These dry residues are potentially usable, among other things, in stabilizing hazardous wastes and as cement additives.

There are three types of fluidized bed combustion being demonstrated in the Clean Coal Technology Program: atmospheric FBC (AFBC), circulating FBC (CFBC), and pressurized FBC (PFBC). Both AFBC and CFBC operate at normal atmospheric pressures; whereas PFBC operates at pressures inside the boiler that are 6 to 16 times higher than normal atmospheric pressure. The fundamental distinguishing feature between AFBC and CFBC is the velocity of the air through the unit. The AFBC has lower fluidization velocities, about 5-12 ft/sec, while CFBCs have velocities as high as 30 ft/sec.⁸

The two sources from FBC processes examined in this study are residues from circulating FBC and pressurized FBC systems. In circulating FBC all residues collected by the cyclone are recycled as shown in Figure 1. There are two main sources of pressurized FBC residues, either from bed-offtake or cyclone discharge, as shown in Figure 2.

FIGURE 1: Circulating FBC Process Showing Residue Sources

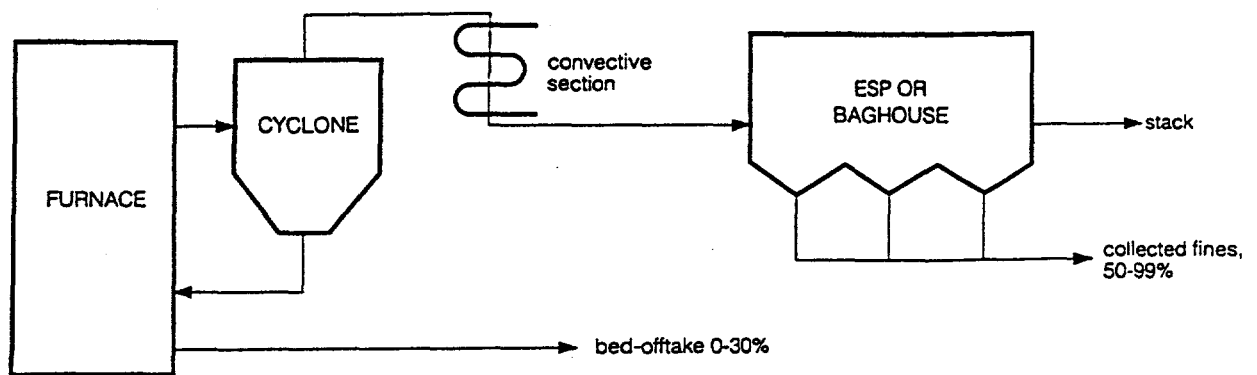
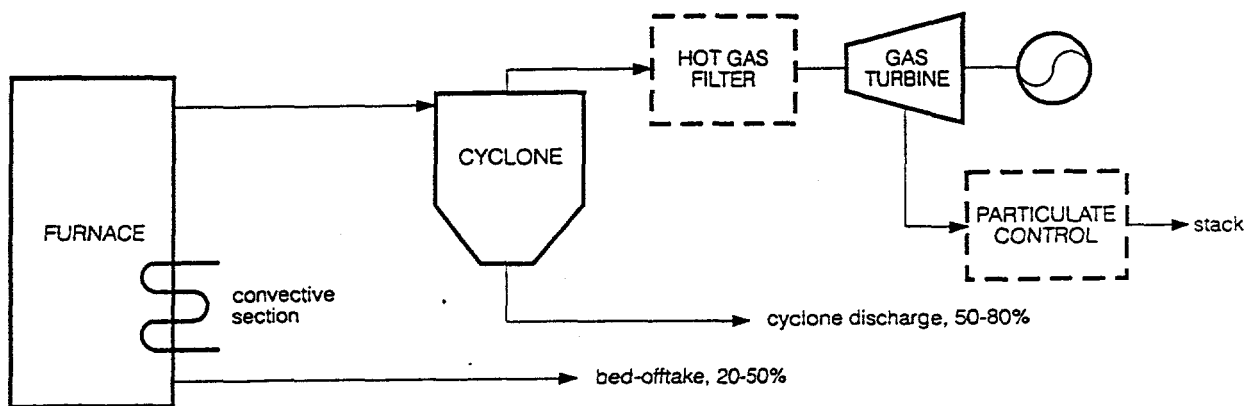


FIGURE 2: Pressurized FBC Process Showing Residue Sources

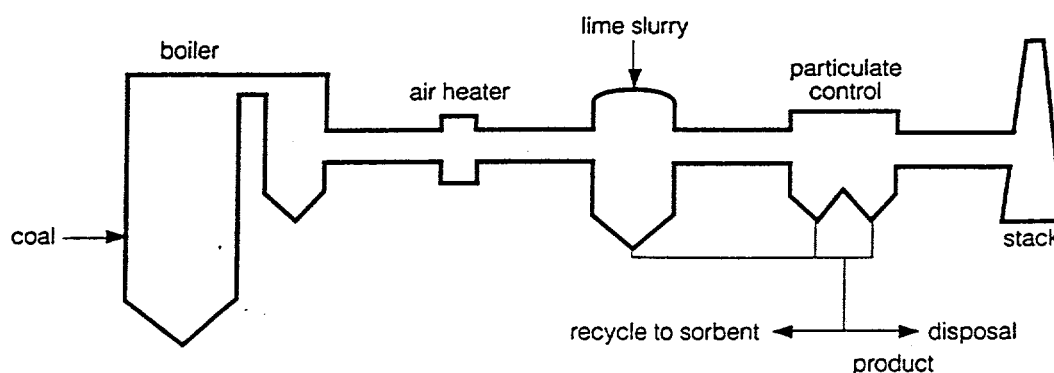


Spray Dry Scrubbers

This technology evolved as an alternative to wet scrubbers and was first used commercially on a coal-fired power station in the U.S. in 1980. Spray dry scrubber processes involve gas/liquid reactions. In spray dry scrubbers an alkaline reagent slurry (usually lime in water) is injected in a finely atomized form into the reaction vessel, which is why these devices are also known as spray dryers. This slurry of alkaline material is mixed with the flue gases at air preheater outlet temperatures.

The flue gases are humidified by finely dispersed droplets. The moisture associated with the entering droplets evaporates in hot gas, drying as it reacts with the SO_2 in the flue gases. As the slurry or solution is evaporated, liquid-phase salts are precipitated and the remaining solids are dried, generally to less than a few percent free moisture. The solids and fly ash, entrained in the flue gases, are carried out from the spray dry scrubber to a particulate collection device, either an electrostatic precipitator (ESP) or fabric filter (baghouse), thus leaving only dry particles for collection as waste. Slaked lime is generally used as a sorbent, although sodium carbonate is used in a few installations. Spray dry scrubbers are designed to achieve 70-95% SO_2 removal but the process has the potential to remove up to 98% of SO_2 . The by-product is a dry mixture of calcium sulphite, calcium sulphate, fly ash, and unreacted lime.⁹ Figure 3 shows a spray dry scrubber process.

FIGURE 3: The Spray Dry Scrubber Process



BY-PRODUCT CHARACTERIZATION

Chemical Properties

The combustion of coal and the subsequent dry pollution control equipment generate a material called "fly ash". The chemical composition of coal fly ash may vary widely because of variation in coal composition, combustion conditions, and ash collection systems. Most fly ashes, however, contain a substantial amount of SiO_2

and Al_2O_3 . The University of North Dakota's Energy & Environmental Research Center's Coal Ash Properties Database (CAPD) shows bituminous coal ashes ranging from 24-65 % SiO_2 and from 12-35 % Al_2O_3 . These types of ashes also generally have low levels of CaO, but are reactive with calcium hydroxide and are termed "pozzolans." The lime-pozzolan reaction forms a low-strength cement. Ashes from low-rank coals, subbituminous and lignite, generally have a higher CaO content with enough CaO free to react with silica, forming a cement. These types of ashes are generally considered cementitious. The CAPD shows a range of 17-65% SiO_2 , 10-25 % Al_2O_3 , and 1-31% CaO for these coal ashes. Other constituents such as alkalis or iron may alter the cementitious or pozzolanic reactions. The bulk chemistry of the coal ash and the wastes to be stabilized and solidified must be compatible for the beneficial reactions to occur.¹⁰

The American Society for Testing and Materials (ASTM) has created specifications for useful coal ashes. An "F Ash" is an ash with a total quantity of pozzolans, i.e., silicon, aluminum and iron oxides equaling or exceeding 70 % by weight of the total ash mass. Some typical examples of "F Ash" are given in Table 1⁷ and the range of oxide compounds specific for "F Ash" is given in Table 2.¹¹

TABLE 1: Typical Percent Specifications For Examples of "F Ash"

Example #	CaO	SiO_2	Al_2O_3	MgO	Na_2O	K_2O	Fe_2O_3	SO_3	LOI
1	6.69	55.1	12.1	1.61	1.73	1.24	5.16	0.52	0.62
2	2.2	48.3	19.4	0.73	2.12	-	11.8	0.56	2.33
3	1.53	44.1	19.6	0.7	0.33	2.39	21.5	0.77	4.93
4	7.48	48.9	22.8	1.54	2.86	0.67	6.09	0.30	0.54

LOI = Lost On Ignition (organic matter volatilized during test)

TABLE 2: Total Oxide Compound Analysis of Typical Fly Ash

Oxide Compound	Range % Composition of Fly Ash
Silicon Dioxide (SiO_2)	30-60
Aluminum Oxide (Al_2O_3)	18-32
Iron Oxide (Fe_2O_3)	3-11
Calcium Oxide (CaO)	1-28
Magnesium Oxide (MgO)	0.5-7.0
Sulfur Trioxide (SO_3)	0-3

The exact composition of sulfur sorption by-products is dependent upon the specific process, coal and sorbent compositions, and plant operating conditions. However, in general these by-products consist of a mixture of conventional ash, unspent sorbent (usually lime or dolomite), and the primary reaction product which is anhydrite (CaSO_4) or calcium sulfite ($\text{CaSO}_3 \cdot 1/2\text{H}_2\text{O}$). Due to their lime contents, dry sulfur sorption by-products are highly alkaline with calcium carbonate equivalents (CCE) in the range of 40-60% and free or available lime contents of up to 25% CaO . These properties may reflect desirable sorption characteristics for use in waste stabilization.⁵

Mineralogical Properties

Of equal importance to the bulk chemistry of the coal ash is the mineralogy. While the bulk chemistry of the coal ash indicates which elements are present and in what quantities, the mineralogy will indicate how those elements have arranged themselves into crystalline structures or minerals. Bituminous coal ashes tend to have relatively few minerals forming in them; quartz (SiO_2) and mullite ($\text{Al}_6\text{Si}_2\text{O}_{13}$) are the dominant ones. Other minerals found in the bituminous coal ashes are hematite (FeO_3) and spinels (MgAl_2O_4). The mineralogy found in low-rank coals often include quartz, mullite, anhydrite (CaSO_4), melilite ($\text{NaCaAlSi}_2\text{O}_7$), hematite, merwinite ($\text{Ca}_3\text{Mg}[\text{SiO}_4]_2$), lime (CaO), and periclase (MgO). These minerals often only constitute 10-40% of the coal ash and are generally non-reactive.

The remainder of the coal ash is usually a glassy or amorphous phase of variable composition. It is the glass-phase that accounts for the pozzolanic and cementitious properties of these ashes. The lime (CaO) found in some of the ashes is the exception, where it can be free to react with the silica, forming a cement when it comes into contact with water. CaO can also be incorporated into the glassy phases where it can be detected by several different analytical techniques.

The mineral content of the coal fly ashes should be considered as part of the overall material properties when a coal fly ash is considered for hazardous waste stabilization and solidification,¹⁰ because most properties of dry sulfur sorption by-products are directly related to their mineralogical composition. The exact composition is an outcome of the injection technology, the coal burned, and the type of sorbent; but, in general, the minerals in ash include reaction by-products (calcium sulfate, calcium sulfite, calcium carbonate, magnesium oxide), unreacted sorbent (lime, hydrated lime, dolomite) and fly ash. Tables 3 and 4 give the typical operating parameters of a 20 MW FBC plant and an example of the mineralogical composition of the FBC ash from the Tennessee Valley Authority's Shawnee Pilot Plant in Kentucky, respectively.¹² Table 5 gives the mineralogical composition of typical spray dryer and PFBC by-products.⁵

TABLE 3: Typical Operating Parameters of a 20-MW FBC Pilot Plant

Calcium-to-Sulfur Ratio	2.4
Sulfur Retention	90%
Recycle Ratio	2.0-2.5
Combustion Efficiency	98%
Bed Depth	4 ft.
Bed Temperature	1530°F
Superficial Velocity	8 ft/sec

TABLE 4: Typical Analysis of the Waste Streams from TVA's 20-MW Pilot Plant

Waste Stream	CaSO ₄	CaO	CaCO ₃	Carbon	Non-Carbonate	Other Ash	Total
Spent Bed %	57.2	28.2	-	-	85.5	14.2	100
Char %	36.5	26.2	4.4	11.3	78.4	21.6	100
FBC Fly Ash	24.6	13.3	4.6	7.6	50.1	49.9	100

TABLE 5: Mineralogical Composition of Typical Dry CCT By-Products (wt %)

Sample	CaSO ₄	CaMg (CO ₃) ₂	CaO	Ca (OH) ₂	CaCO ₃	CaSO ₃ 1/2H ₂ O	MgO	Fly Ash	Total
Spry Dryer	ND	ND	ND	30	17	30	ND	21	98
PFBC Bed Ash	36	ND	3	ND	27	ND	27	10	103
PFBC Cyclone Ash	22	23	ND	ND	11	ND	13	32	101

ND = Not Detected

These typical mineralogical results show that scrubber residues from a spray dryer consist primarily of Ca(OH)₂ (portlandite) and CaSO₃·1/2H₂O (calcium sulfite hemihydrate). This phase is indicative of low flue gas reaction temperatures in the range of 150-200°C. Bed ash from the PFBC facility is enriched with CaSO₄, CaCO₃ and MgO (periclase), which is derived from calcination of the dolomite [CaMg(CO₃)₂] sorbent; whereas cyclone material contains mostly CaMg(CO₃)₂ and CaSO₄ and contains less MgO. The dry sulfur sorption material described here contained 10-32% fly ash arising from coal combustion. Chemical analyses of coal fly ash residues from the by-products are dominated by Al, Fe, and Si. This chemistry is consistent with fly ash mineralogy.

Physical Properties

The bulk density of coal ash is important when a fly ash is considered for a stabilization and solidification application. Bulk density, specific gravity, and moisture content are properties used in the stabilization and solidification process to calculate porosity, which is of prime importance for the entrapment of contaminated particles. Fineness of a coal ash is an important physical property, with the finer ashes being more desirable because they tend to decrease the porosity of the solidified wastes. Fineness is a difficult property to measure directly, however, therefore specific surface area measurements are used instead, with higher surface areas indicating finer particles. The fineness of the coal ash affects the development of the cured product in that the finer the pozzolanic particles are, the stronger the end product is.¹⁰

Some typical physical properties of representative dry sulfur sorption by-products are given in Table 6.^{6,13}

TABLE 6: Physical Properties of Selected Dry Sulfur Sorption By-Products

Sample	No. Samples	pH	CCE CaCO ₃ %	Surface Area m ² /g	Particle Density g/cm ³	Bulk Density g/cm ³	Temperature Reactivity °C/20min
FBC Bed Ash	1	12.39	39.5	--	--	--	--
FBC Cyclone Ash	1	12.48	39.2	--	--	--	--
Spray Dyer	5	12.3	65.2	13.5	2.39	.59	1
PFBC Bed Ash	7	11.9	66.0	0.9	2.92	1.29	<1
PFBC Cyclone Ash	7	9.8	61.9	2.8	2.76	1.29	<1

Table 6 shows that the sulfur sorption by-products have calcium carbonate equivalents (CCE) ranging from 39.2-66.0 % as percent CaCO₃. The dry sulfur

sorption by-product from the spray dryer has a relatively high surface area (13.5 m²/g) and is found to pass a 100 mesh sieve (i.e. like fly ash).⁶

Leaching Properties

When a waste is exposed to water a rate of dissolution can be measured, this process is called leaching. The contaminated water that passes through the waste is the leachate and the capacity of the waste material to leach is called its leachability. Leaching is a rate phenomenon and is of interest, environmentally, as the rate at which hazardous or other undesirable constituents are removed from the waste and passed into the environment via the leachate. This rate is usually measured and expressed, however, in terms of concentration of the constituents in the leachate.¹⁴ Leaching tests are often used to evaluate the availability and/or mobility of various constituents in wastes, including coal ash, which is frequently considered a waste for regulatory purposes.¹⁰

The Toxicity Characteristic Leaching Procedure (TCLP) is the federally mandated EPA regulatory procedure for determination of hazardousness. The TCLP leachate must be analyzed for an extensive list of organic constituents and trace elements to determine the hazardousness of a particular material or waste.¹⁰ Table 7 gives a comparison of water and acid TCLP leachate from a Pyporpower, 300,000 lb per hour CFBC rated at 28 MW and operated by General Motors in Pontiac Michigan; a Babcock & Wilcox designed PFBC called the Tidd Plant in Brilliant Ohio, which has a gross electrical output of 74 MW and produces both cyclone and bed ash; and a Joy Environmental spray dryer designed for a gas flow of 82,000 atmosphere cubic feet per minute operated by the Ohio State University Power Plant at Columbus, Ohio.⁵

TABLE 7
Comparison of Water and Acid TCLP Leachates
From Representative Dry Sulfur Sorption By-Products

All results given in mg/L

Sample		CFBC	PFBC cyclone	PFBC bed	Spray Dryer
Ag (Silver)	TCLP	<0.024	<0.024	<0.024	<0.024
	Water	0.007	<0.005	<0.005	0.007
As (Arsenic)	TCLP	<0.005	<0.005	<0.005	<0.005
	Water	<0.005	<0.005	<0.005	<0.005
Ba (Barium)	TCLP	0.693	0.141	0.141	0.348
	Water	0.310	0.166	0.202	0.292
Cd (Cadmium)	TCLP	<0.003	<0.003	<0.003	<0.003
	Water	<0.001	<0.001	<0.001	<0.001
Cr (Chromium)	TCLP	<0.005	0.011	<0.005	0.009
	Water	<0.011	<0.011	<0.011	<0.011
Cu (Copper)	TCLP	<0.013	<0.013	<0.013	<0.013
	Water	<0.007	<0.007	<0.007	<0.007
Hg (Mercury)	TCLP	<0.0002	<0.0002	<0.0002	<0.0002
	Water	<0.0002	<0.0002	<0.0002	<0.0002
Ni (Nickel)	TCLP	<0.011	<0.011	<0.011	<0.011
	Water	<0.10	<0.10	<0.10	<0.10
Pb (Lead)	TCLP	0.002	<0.001	<0.001	0.017
	Water	<0.001	<0.001	<0.001	0.012
Se (Selenium)	TCLP	0.005	<0.001	0.001	0.004
	Water	<0.005	<0.005	<0.005	<0.005
Zn (Zinc)	TCLP	<0.006	<0.006	<0.006	<0.006
	Water	<0.006	<0.006	<0.006	0.007
pH	TCLP	12.12	9.58	9.61	11.98
	Water	12.01	11.42	11.77	12.26

Reports in literature indicate that very low concentrations of trace elements most likely present in coal ash are present in the leachates generated from coal ash. The literature also indicates that wastes stabilized with coal ash leach low concentrations of these trace elements.¹⁰

As with determining hazardousness, the effectiveness of remediation is also often determined using a leaching test. Stabilization and solidification are performed to reduce the leachability or mobility of potentially hazardous constituents to below the point of hazardousness.¹⁰ To find out the likely environmental consequences of utilizing residues, an understanding of the leaching characteristics is required. Knowledge of the morphology and composition of residues may aid prediction of leaching behavior.¹⁵

When portland cement is compared to quality "F Coal Fly Ash" in the matter of toxic metals that can be acid leached, it is worth noting that the ASTM "F Ash" does as well or better than many commercial portland cements, a material many consider the premier pozzolanic material. Examples of acetic acid (H_2CO_3) extraction testing produced the data given below in Table 8.⁷

TABLE 8: Leaching of Toxic Metals in Portland Cement and "F Fly Ash"

Reagent Name	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel
Portland Cement Type I	<0.420	0.840	0.010	--	--	0.250	<0.001	--
Portland Cement Type I	<0.010	1.010	<0.010	0.260	0.180	0.260	<0.001	0.020
Portland Cement Type II	<0.010	1.770	<0.010	0.240	0.210	0.340	<0.001	0.020
F Fly Ash	0.030	0.053	<0.005	0.310	0.240	<0.025	<0.0002	0.160

The leaching characteristics of the coal fly ash should be considered before the fly ash is used in stabilization and solidification application. Trace element mobility

(leachability) in coal fly ashes can be characterized for individual materials, but not for generalized categories of coal by-products. Each individual coal ash should be assessed for leachability before it is used in a stabilization and solidification process, as a coal fly ash with highly mobile constituents may not be suitable material for hazardous waste stabilization.¹⁰

Hydration Reactions

When coal fly ash is added to cement, it tends initially to retard the cement hydration reactions, but then accelerate them during most of the reaction. The major reaction between the cement and fly ash is the formation of calcium silicate hydrate caused by the calcium hydroxide in the cement reacting with the glassy silica in the fly ash. The aluminum contained in the glassy portion of the coal fly ash also forms calcium aluminum hydride, or if sulfur is also present, ettringite ($\text{Ca}_6\text{Al}_2[\text{SO}_4]_3[\text{OH}]_{12}\cdot 26\text{H}_2\text{O}$) can also form.

The formation of the mineral ettringite is an important hydration product for many coal fly ashes and other types of coal combustion by-products. It forms when there are sufficient amounts of calcium, aluminum, and sulfur available from the glassy portions of the ash and pH conditions are greater than 11.5.

When coal fly ash is used as a pozzolanic admixture in concrete, it helps remove the calcium hydroxide in the cement that is subject to chemical attack. It is theorized that the calcium silicate levels in the mixture are higher than in plain portland cement, increasing the protective action of the calcium silicate hydrate.¹⁰

High calcium fly ashes have hydration reactions that result in the formation of ettringite ($\text{Ca}_6\text{Al}_2[\text{SO}_4]_3[\text{OH}]_{12}\cdot 26\text{H}_2\text{O}$); monosulfate ($\text{Ca}_4\text{Al}_2\text{SO}_4[\text{OH}]_{12}\cdot 6-7\text{H}_2\text{O}$); and stratlingite ($\text{Ca}_2\text{Al}_2\text{SiO}_7\cdot 8\text{H}_2\text{O}$). It has been found that ettringite formation is beneficial and reduces the amount of leachable selenium and boron in contaminated samples of coal fly ash and advanced combustion residues.¹⁰

CONCLUSION

Today there are a variety of by-products produced from coal combustion. Besides

fly ash and bottom ash from pulverized coal combustion, which comprise the bulk of coal-use residues, there are residues from many new technologies developed to control the emission of gaseous air pollutants. As electricity production increases and additional flue gas desulfurization treatment plants are fitted to power stations, so the quantities of residues are set to increase and produce additional challenges for by-product management.¹⁴

The exact composition of a dry sulfur sorption by-product is dependent upon the specific process, coal and sorbent compositions, and plant operating conditions. However, upon completing a literature review on CCT by-products, it was found that, in general, these by-products consist of a mixture of conventional fly ash, unspent sorbent (usually lime or dolomite), and the primary reaction product which is anhydrite (CaSO_4) or calcium sulfite ($\text{CaSO}_3 \cdot 1/2\text{H}_2\text{O}$). Because of their lime contents, dry sulfur sorption by-products are highly alkaline with calcium carbonate equivalents (CCE) in the range of 40-60% and free or available lime contents of up to 25% CaO . These properties may reflect desirable sorption and cementitious characteristics for use in metal-laden hazardous waste stabilization and solidification.⁵

The successful outcome of this research project offers many benefits. Operators of U.S. coal powered electric plants, who generate about 70,650 kilotons of ash per year¹⁴, would benefit greatly if utilization of the massive amounts of fly ash from these coal-fired plants as reagents could be defined, as it would reduce the quantity and cost of landfilling these residues as wastes. People in the business of remediation of hazardous wastes could also benefit by seeing how coal fly ash chemistries work to reduce the leachability or mobilities of heavy metals such as lead without resorting to "reagent dilution" to achieve meaningful results. A company involved in waste treatment might also be interested in learning what the differences between general classes of coal fly ash are when it comes to toxic control and waste strength properties after treatment. Coal fly ashes are widely available and if it can be demonstrated that the utilization of CCT by-products can result in successful technical results that are cost effective then the producers of by-products could be linked with the operators of hazardous waste treatment facilities in a mutually beneficial manner and the objectives of this research project will have been met.⁷

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13. "Land Application Uses for Dry FGD By-Products", Phase I Report, Ohio State University, April, 1993.
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- D. L. Cocke, "The Binding Chemistry And Leaching Mechanisms Of Hazardous Substances In Cementitious Solidification/Stabilization Systems", *Journal of Hazardous Materials*, 24:231-253, 1990.
- J. C. Burnham, "Use Of Coal Ash Products As Alkaline Admixtures in the Sludge Stabilization Process", Paper presented at the American Coal Ash Association 10th Coal Ash Symposium, January 17-23, 1995.
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- "Final Regulatory Determination On Four Large-Volume Wastes From The Combustion Of Coal By Electric Utility Power Plants", Environmental Protection Agency, September 2, 1993.
- D. Jagiella, "Coal Combustion By-Product State Regulatory Overview", Howard & Howard Attorneys, P.C., Peoria, Illinois.
- S. S. Tyson, "Overview of Coal Ash Use In The USA - Pollution Prevention For The 21st Century", Prepared for Air & Waste Management Association Annual Meeting, Denver, CO, June 14-18, 1993.
- R. Hamric, "Utilization Of CFB Ash In Reclamation To Prevent Post-Mining AMD", Anker Energy Corporation, March 1993.
- "Integrated Gasification Combined Cycle", U.S. Department of Energy, Morgantown Energy Technology Center.
- R. L. Smith, "Procedure For Evaluating Coal Fly Ash For Use In Waste Stabilization/Solidification", Presented at American Coal Ash Association 9th Coal Ash Symposium, Orlando, Florida, January, 1991.
- D. A. Adams and W. E. Wolfe, "The Potential For Swelling In Samples Of Compacted Flue Gas Desulfurized By-Product", Presented at American Coal Ash Association 10th Coal Ash Symposium, Orlando, Florida, January 17-23, 1993.

APPENDIX C

Stabilization and Solidification:

REVIEW OF WASTES AND TREATMENTS

Barth, Edwin F., et al, *Stabilization and Solidification of Hazardous Wastes*. Noyes Data Corporation, Park Ridge, New Jersey, 1990.

This Handbook provides a means of interpreting information on stabilization/solidification (s/s) treatment. Included are discussions on inorganic and organic s/s and a listing of current and proposed s/s activity in various U.S. EPA regions. The text discusses various physical tests to characterize wastes before and after s/s including compaction testing, density testing, permeability testing, strength testing, and durability testing. It also discusses various chemical testing procedures including leaching test methods and applications.

Conner, Jesse R., *Chemical Fixation and Solidification of Hazardous Wastes*. Van Nostrand Reinhold, New York, 1990.

This text is a general reference work on the basis and applied chemistry of chemical fixation and stabilization technology. It provides information about the history and background of cfs and discusses the principles of fixation of metals, inorganics, and organics. Extensive information is contained concerning the various cfs systems including portland cement, portland cement/soluble silicate processes, lime/flyash and other lime-based processes, portland cement/flyash processes, and kiln dust and flyash-based processes.

Gilliam, T. Michael and Wiles, Carlton C., ed., *Stabilization and Solidification of Hazardous, Radioactive, and Mixed Wastes, Second Volume*. ASTM Publication, Philadelphia, 1992.

This publication contains papers presented at the Second International Symposium on Stabilization/Solidification of Hazardous, Radioactive, and Mixed Wastes, which was held in Williamsburg, Virginia, 29 May to 1 June 1990. Included are papers on laboratory-scale leachability studies which may provide useful information.

Stegemann, J.A and Cote, P.L., *Investigation of Test Methods for Solidified Waste Evaluation - A Cooperative Program*. Environment Canada and the United States Environmental Protection Agency, Report EPS 3/HA/8, January 1991.

This report documents a study to develop and validate 16 laboratory test methods for evaluating the physical and chemical properties of solidified wastes. This report may provide useful information concerning the validity of the testing procedures we will be using.

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Cote, Pierre and Gilliam, Michael, ed, *Environmental Aspects of Stabilization and Solidification of Hazardous and Radioactive Wastes*. ASTM Publication, Philadelphia, 1989.

This publication contains papers that were presented at the Fourth International Hazardous Waste Symposium on Environmental Aspects of Stabilization/Solidification of Hazardous and Radioactive Wastes held 3-6 May 1987 in Atlanta, Georgia. Papers on leaching characteristics and solidification processes should provide applicable information.

Spence, Roger D. , ed., *Chemistry and Microstructure of Solidified Waste Forms*. Lewis Publishers, Boca Raton, 1993.

This publication contains proceedings from the Chemistry and Microstructure of Solidified Waste Forms Symposium sponsored by the Environmental Division of the American Chemical Society and the ACS National Meeting in New York City on August 25 to 30, 1991. The symposium and its proceedings were limited to cementitious, or cement-based, solidified/stabilized waste forms including lime and fly-ash combinations. Information is presented on chemistry and microstructural characterization of solidified/stabilized waste forms.

Hazardous and Metal Waste Treatment:

The following publications provide general information on hazardous waste and metal waste treatment technologies, including proven and state of the art treatment technologies.

Krishnan, E. Radha, et al, *Recovery of Metals from Sludges and Wastewaters*. Pollution Technology Review No. 207, Noyes Data Corporation, New Jersey, 1993.

U.S. Environmental Protection Agency, *Mercury and Arsenic Wastes, Removal, Recovery, Treatment, and Disposal*. Pollution Technology Review No. 241, Noyes Data Corporation, New Jersey, 1993.

Palmer, S. A. K., et al, *Metal/Cyanide Containing Wastes, Treatment Technologies*. Pollution Technology Review No. 158, Noyes Data Corporation, New Jersey, 1988.

U.S. Environmental Protection Agency, *Land Disposal, Remedial Action, Incineration and Treatment of Hazardous Waste, Proceedings of the Fourteenth Annual Research Symposium*. Office of Research and Development, Risk Reduction Engineering Laboratory, Cincinnati, 1988.

Wang, Lawrence K. and Wang, Mu Hao Sung, *Handbook of Industrial Waste Treatment, Volume 1*. Marcel Dekker, Inc., New York, 1992.

Nemerow, Nelson L. and Dasgupta, Avijit, *Industrial and Hazardous Waste Treatment*. Van Nostrand Reinhold, New York, 1991.

APPENDIX D

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METC's RECORD OF THE KICK-OFF MEETING

United States Government

Department of Energy

memorandum

DATE: November 18, 1994

REPLY TO

ATTN OF: METC/EWM

SUBJECT: Meeting Record, University of Pittsburgh, Treatment of Metal-Laden Hazardous Wastes with Clean Coal Technology Solid By-Products

TO: William J. Huber, Acting Director, Environmental and Waste Management Division

MEETING RECORD

Date of Meeting: November 10, 1994.

Location: Morgantown Energy Technology Center (METC).

Participants: M. Ashbaugh, R. Bedick, S. Bossart, V. Kothari, J. Malhotra (METC); S. Buckley (American Electric Power [AEP] Services Corporation); J. Roewer (Edison Electric Institute); R. Chu (Ohio Coal Development Office); S. Tutokey, J. Beeghly (Dravo Lime); C. Bender (Mill Service); J. Cobb, J. Pritts, R. Neufeld (University of Pittsburgh).

Purpose of Meeting: Project kickoff meeting.

Discussion: Jim Cobb (University of Pittsburgh) presented an overview of the project. The purpose of this project with the University of Pittsburgh is to develop a technology to treat hazardous industrial wastes using solid by-products from Clean Coal Technologies (CCT). The technology must be technically, economically, and environmentally viable, and acceptable to regulators and the public. A regulatory goal of the project is to clarify and resolve indemnification issues concerning use of coal by-products for treatment of hazardous waste. The use of solidified waste for potential structural applications, such as fills, caps, and building blocks, will be investigated in the project. The project is divided into two 1-year phases. In Phase 1, up to 10 sources of metal-laden hazardous wastes will be treated with up to 4 sources of CCT solid by-products in laboratory-scale tests. In Phase 2, metal-laden hazardous waste will be treated using CCT solid by-products in 20-ton batches. Complete physical and chemical characterization of the CCT solid by-products, and treated and untreated metal-laden hazardous waste will be performed in both phases. An economic analysis is included in both phases to assess the commercial viability of treating metal-laden hazardous waste with CCT solid by-products. Participants on the project are the Chemical and Civil Engineering Departments of the University of Pittsburgh, Mill Service, Dravo Lime, and the University of Pittsburgh's Center for Hazardous Materials Research.

The four by-products selected for study are a flyash from a coal-fired circulating fluidized-bed combustion (CFBC) at the AES Thames River Co-generation Plant, a mixed-ash from a coal waste-fired CFBC at the Ebensburg Power Plant, flyash from a coal-fired PFBC at the Ohio Power Company Tidd station, and a spray drier effluent from a PC boiler Carneys Point Co-generation Plant. Currently, the flyash from AES Thames is shipped by rail to the Albright mine. However, a contract is being negotiated with AES Thames to ship the flyash to the Porter site in eastern Pennsylvania for remediation of an anthracite culm. This negotiation will slightly delay acquisition of samples. Metal-laden hazardous wastes to be investigated include cyclone dusts, sandblasted paint, thickened sludges, and contaminated soils. Sources of the hazardous wastes will not be identified. Dravo Lime will collect three 20-gallon and seven 5-gallon samples of each coal by-product. They will analyze the samples and distribute them to Mill Service and the University of Pittsburgh. Mill Service will determine the effective level of treatment of each metal-laden waste with each coal by-product. They will prepare 3-inch diameter by 6-inch long cylinders of the treated material. The University of Pittsburgh will run ASTM and TCLP leachate tests on the coal by-products and treated waste. They will determine the compressive strength of the treated waste over time. They will also evaluate the economics of the treatment technology, and assess the regulatory climate regarding indemnification and liability issues. Important parameters for the economic study include price of coal by-product, transportation costs, amortization of special equipment, operating costs, and disposal costs. The economic study will include a sensitivity analysis on important variables. Economics of the solidification of metal-laden waste with coal by-products will be compared with the cost of current practices for treating the metal-laden wastes.

Joel Beeghly (Dravo Lime) discussed Dravo's approach to sample the four coal by-products. The flyash from AES Thames River will be sampled from the top of a rail car. The flyash sample will contain unhydrated free lime. The bed ash and flyash from Ebensburg Power Company will be sampled by their personnel from a storage silo. This sample will also contain unhydrated free lime. The baghouse flyash and spray dryer ash from Carney's Point will be sampled by CONSOL. This sample will contain hydrated free lime. The sample from the Tidd PFBC has cyclone ash, plus 2-3 percent electrostatic precipitator ash. This sample will have no free lime, but it will have free magnesia from the dolomite sorbent. The coal by-products will be analyzed for moisture, calcium oxide, magnesium oxide, silicon oxide, iron oxide, alumina, total sulfur, sulfate, sulfite, and loss of ignition. Also, thermal reactivity, alkalinity, carbonate, available lime, pH, and mixed waste ratio will be measured. The mixed waste ratio measures the amount of coal by-product required to solidify a gallon of water. Preliminary results showed that

the 20 pounds of Tidd ash were needed to solidify a gallon of water. Dravo will also measure specific gravity, bulk density, Blaine fineness, surface area, and particle size distribution of the coal by-products.

Carl Bender (Mill Service) discussed the role of Mill Service in the project. Mill Service began their hazardous waste treatment business in 1957, and has an active plant in Yukon, Pennsylvania, and an inactive plant in Bulger, Pennsylvania. They are licensed to handle corrosive materials, all RCRA metals except mercury, spent pickle liquor, and non-hazardous residual wastes. Each waste undergoes a rigorous evaluation process before it can be accepted for treatment at the Yukon site. Mill Service has three double-lined mixing chambers for treating hazardous waste. Each chamber has an outer liner of 18 inches of reinforced concrete, and an inner liner of 3/4 inch steel. The chambers are about 15 feet by 30 feet and 12 feet deep. The sandblast wastes to be used in this project will be from a bridge painting project, and could contain lead, chromium, and cadmium. The sludges will be from a wastewater treatment system at a battery manufacturing facility and an emission control system installed on a basic oxygen furnace. The contaminated soils will probably contain lead and cadmium. Dust from air pollution control devices will include dust collected from an air pollution control system installed on a basic oxygen furnace, and flyash collected in an air pollution control system installed on a municipal waste incinerator. Mill Service uses about 1 gallon (or 10 pounds) of material in the treatment feasibility tests. The effectiveness of treatment will be evaluated by the ability of the treated waste to meet TCLP limits and Best Demonstrated Available Technology (BDAT) treatment standards for land disposal restrictions (LDR). Except for selenium, BDAT and TCLP limits are currently the same. However, on September 19, 1994, the Environmental Protection Agency recommended lower BDAT standards for the eight RCRA metals, and added nickel, zinc, antimony, beryllium, thallium, and vanadium to the list of metals regulated under the LDR.

Ron Neufeld (University of Pittsburgh) discussed the approach to chemically characterize the coal by-products. Dravo will conduct elemental chemical analysis on the coal by-products. Mill Service will chemically digest the by-products and measure silver, arsenic, barium, cadmium, chromium, lead, mercury, and cerium. The University of Pittsburgh will measure copper, nickel, and zinc. For the hazardous waste materials, Mill Service will measure 11 heavy metals, and conduct TCLP tests. Mill Service will treat the metal-laden hazardous wastes with the coal by-products using different ratios of coal by-product to hazardous waste. Mill Service will conduct TCLP tests on the treated materials, and prepare test cylinders. The University of Pittsburgh will measure the compressive strength of the cylinders

at 3, 7, 14, 28, and 90 days. They will also conduct ASTM leaching tests on stabilized material (not cylinders).

Additional research that could be considered in the project includes addition of more sources of coal by-products, evaluation of additional metals associated with the drinking water standards (i.e., antimony, nickel, thallium, beryllium, vanadium), accelerated aging tests (e.g., freeze-thaw), effect of particle size of coal by-product on stabilization, and detailed materials analysis by SEM, XRD, and TGA. Two graduate students will work on this project. A copy of the presentation materials is available in my office.

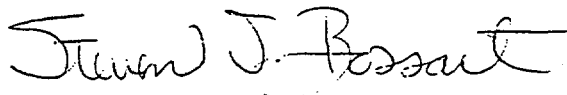
Steve Bossart made a presentation on METC's Fossil Energy Waste Management Program.

Action Items:

Send copy of METC presentation to Jim Cobb (Bossart).

Send copy of Report to Congress to Richard Chu and Ron Neufeld (Bossart).

Make copy of project presentation materials for R. Bedick (Bossart).



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:jlc

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